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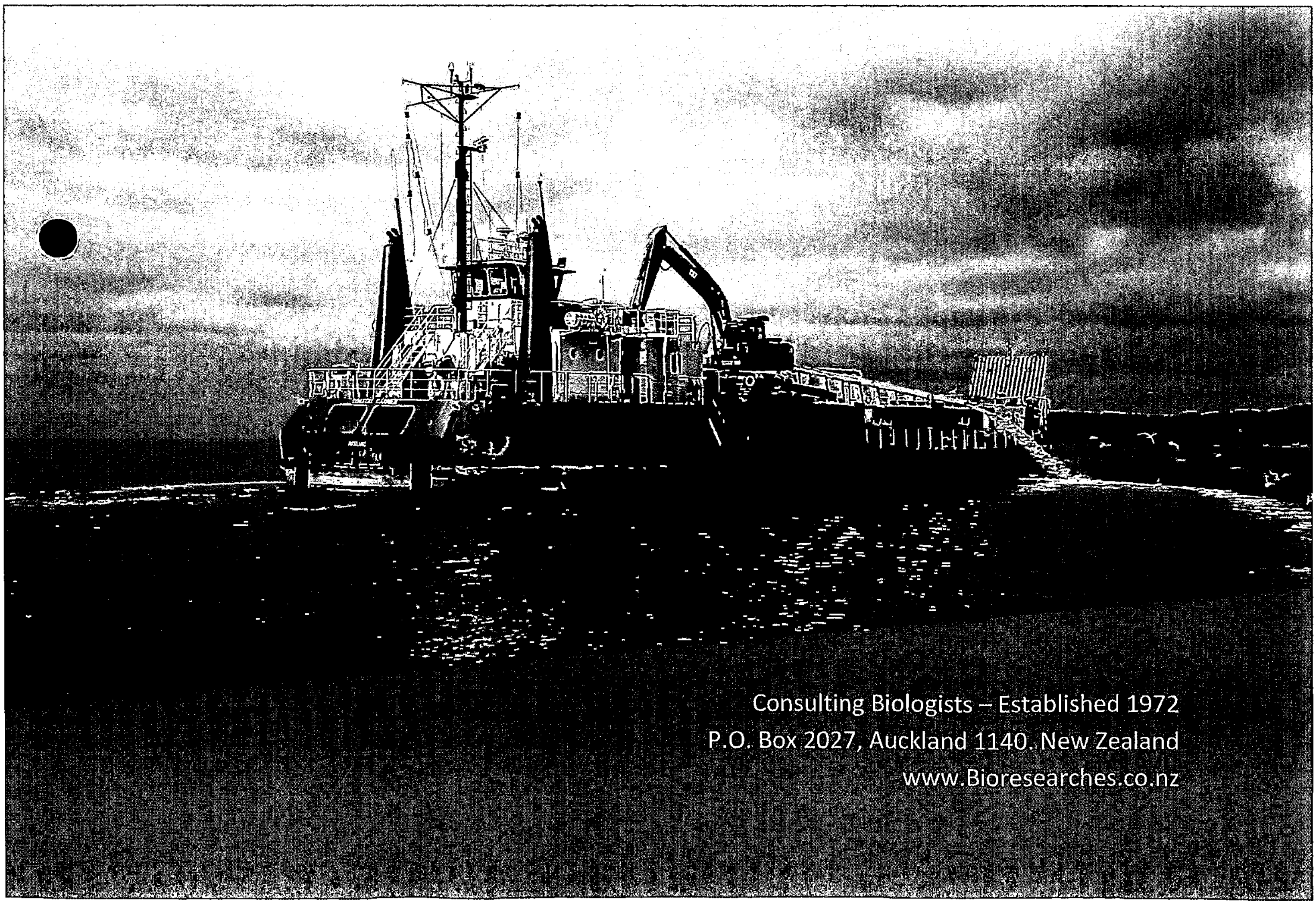
Assessment of Ecological Effects: Following Sand Extraction from the Auckland Offshore Sand Extraction Site

December 2017



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Cover Illustration: Sand dredge in operation off Pakiri beach (May 2019)

CONTENTS

1. INTRODUCTION

In 2000 Kaipara Ltd (Kaipara) was granted a Resource Consent (Coastal Permit 20795) from the Auckland Regional Council to extract up to 2 million cubic metres of sand from the sea floor within an area of ~ 636 km² of the Hauraki Gulf (Figure 1.1) over 20 years beginning in February 2003. That decision was subsequently appealed to the Environment Court in 2001. The Environment Court re-affirmed the recommendation to the Minister of Conservation to allow deep sand extraction from the Hauraki Gulf. The permit includes allowances for the extraction of sand via dredging, to discharge excess sea water, shell and sand and to temporarily occupy the coastal marine area while dredging. Sand is currently extracted from two areas within the Auckland Offshore Sand Extraction Site as outlined in Figure 1.2. Typically the sand is extracted from the seabed in the depth range between 25 and 30 m. Between 2016 and 2018 the typical monthly volume of sand extracted has been 20,500 m³, however the extracted volume has declined from as high as 27,500m³ in November 2016 to a low of 10,500 m³ in January 2018. The rate of sand extraction is only limited by the availability of suitable weather conditions and equipment breakdowns. In recent years the majority of sand extraction has occurred in the southern Area 1. Hence Area 1 was selected as the most likely area to be effected based on sand extraction. As part of the consent application it is proposed to reduce the currently consented area (Figure 1.1) for sand extraction to the Auckland Offshore Sand Extraction Site as outlined in blue in Figure 1.2.

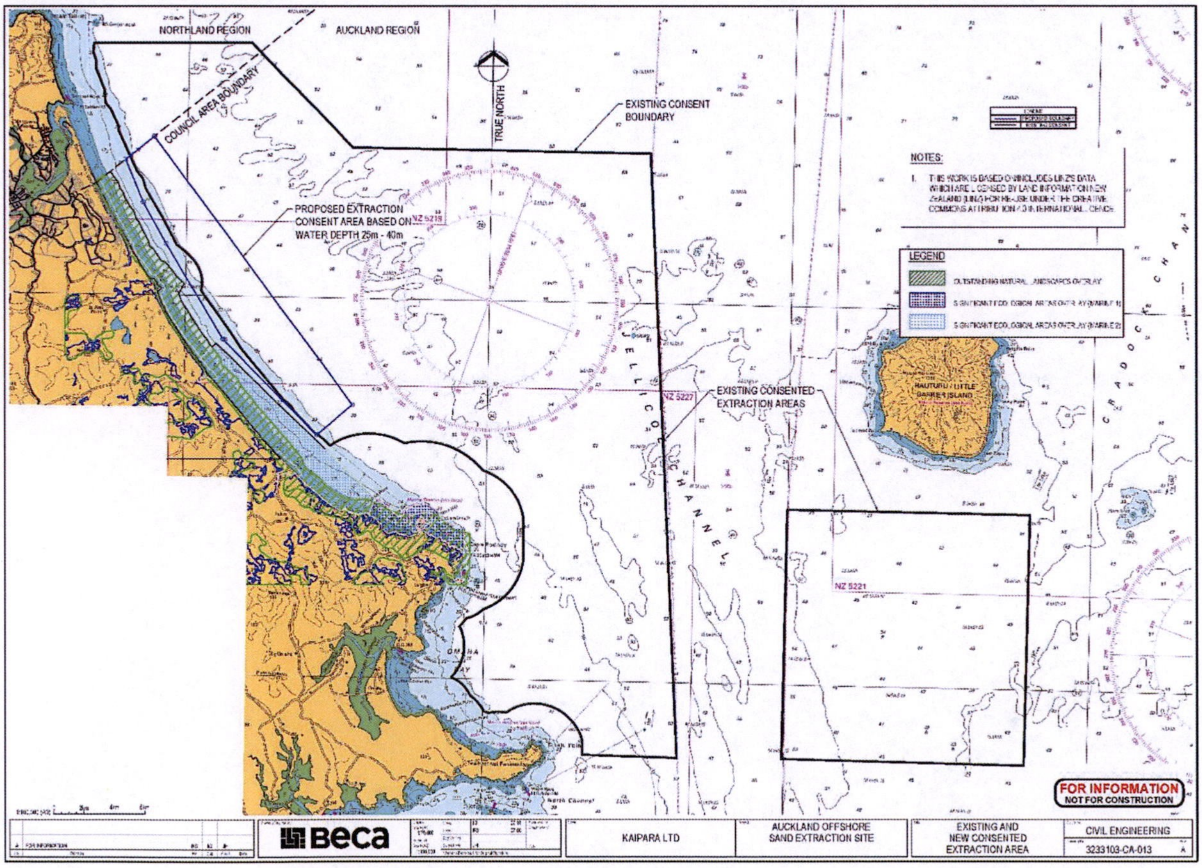

Figure 1.1 Chart showing general extent of currently consented extraction area and proposed extraction area

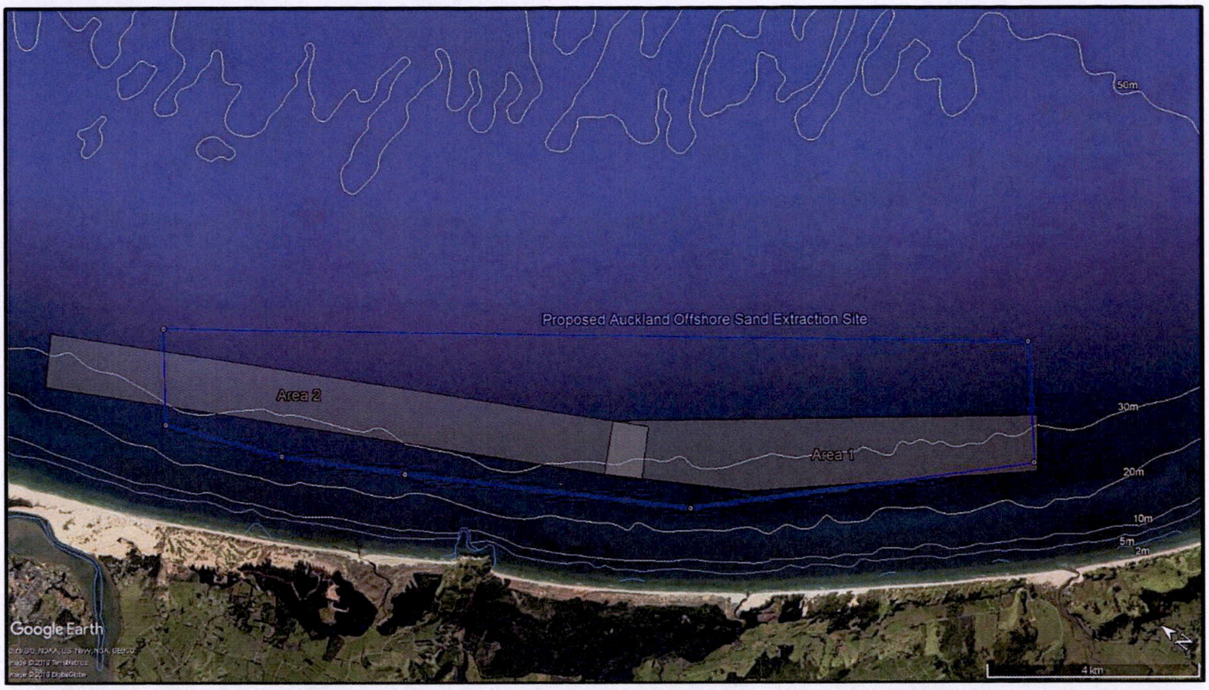

Figure 1.2 Location of the approved sand extraction areas (Area 1 and Area 2) 2003 – 2019, and the Proposed Auckland Offshore Sand Extraction Site

Before and after comparative data on benthic biota and sediment grain size characteristic from the current consented sand extraction area was not available with which to assess any potential effects. This report presents a comparative analysis of the sediment texture data collected by ASR and the University of Waikato in 2003 before dredging, and by Bioresearches in 2011 and 2017 after dredging within and adjacent to Area 1. It also presents a comparative analysis of the benthic biota data collected by ASR and the University of Waikato in 2003 before dredging, and by Bioresearches in 2017 after dredging within and adjacent to Area 1. Both comparisons assessed against the changes observed in the control area to the south of Area 1 surveyed in 2011 and 2017 by Bioresearches.

2. METHODS

2.1 Pre-Sand Extraction Surveys

The initial ecological surveys conducted by ASR in 2003 (Area 1) and 2006 (Area 2) used a range of sampling techniques; grab samples, video survey and dredge tows.

Prior to sampling in 2003 side-scan sonar data was used to identified four seabed types;

1. Coarse grain ripple (26%)
2. Coarse grain ripple with fine sand fingers (14%)
3. Transition from coarse grain ripple to featureless fine sand (18%)
4. Horse mussels and fine sand fingers (42%)

The location of sampling sites was designed so that the relative percentage of samples within each of the seabed types was identical to the coverage extent of that type of seabed. Sites were randomly selected within each seafloor type area and at the appropriate proportion with respect to the coverage of the total area (e.g. coarse grain ripple represents 26% of the area so 13 of the 50 grab samples were taken in this area). Positions of sample sites are listed in Appendix 1.

2.1.1 Grab samples

A total of 65 grab samples were collected using a Smith-Macintyre grab sampler, 50 within Area 1 and 15 outside this area by a minimum distance of 300 m as reference sites (Figure 2.1). Each grab sample had a sediment load of 1 - 2 L, with a bite depth corresponding to approximately 100 mm. The area sampled by the grab sampler was not specified. Similarly, a total of 65 sites inside Area 2, and an additional 35 sites outside Area 2 were defined in 2006 (Figure 2.2). However, a Ponar Grab sampler was used for these sites resulting in each sample with a volume of 800 - 1000 ml, with a bite depth of approximately 100 mm.

A small fraction of each sample from the Area 1 sites was removed and stored for later grain size analysis.

Samples were sieved using 1 mm mesh and all living organisms were preserved in 5% buffered formalin in seawater. In the laboratory, samples were rinsed through a 0.5 mm sieve and allowed to de-gas overnight. Specimens were identified to the lowest taxonomic group possible, and then stored in 70% ethanol. Only animals with heads intact were counted and identified.

The grab sample data were then compiled and analysed to provide a description of the macrobenthic community structure (species richness and evenness). The Shannon-Weiner diversity index is used as a measure of species richness (i.e. the total number of different organisms present), which takes into account the proportion of each species within the survey area (i.e. the diversity of the population).

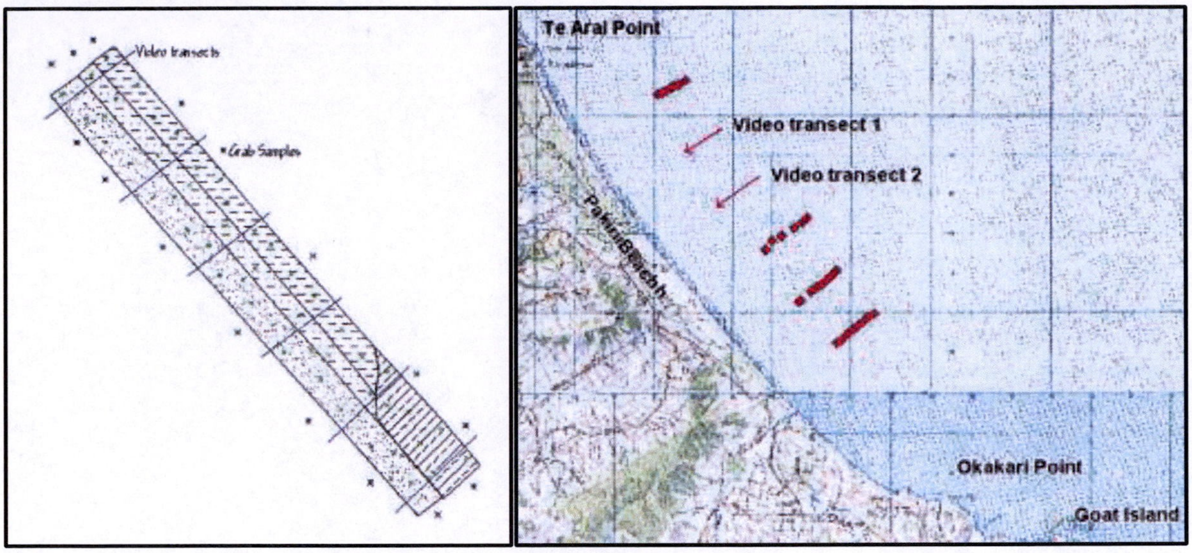

Figure 2.1 2003 Area 1 sample locations (from ASR, 2003)

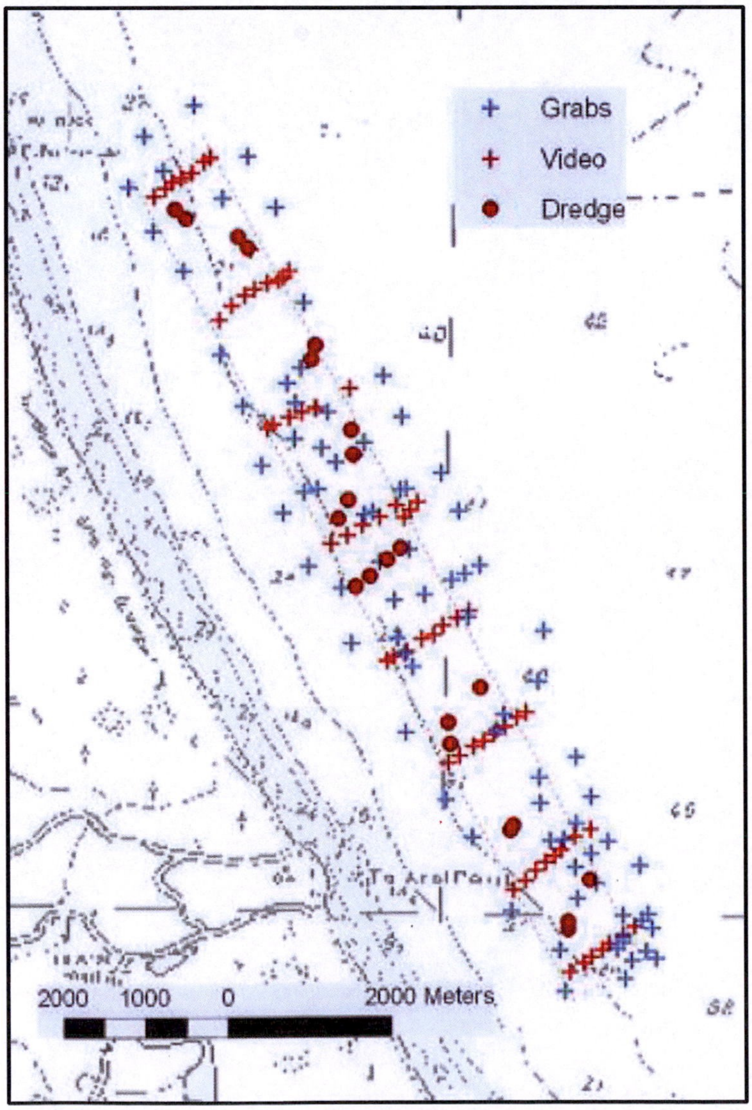

Figure 2.2 2006 Area 2 sample locations (from ASR, 2006)

2.1.2 Video survey

In 2003 six video transects in Area 1 (each >1 km long) were planned to be undertaken by towing a stabilised submersible video camera behind the research vessel (Figure 2.1). However, only two transects were recorded due to technical issues. Instead, a drop-camera was used to survey the seabed at 100 m intervals along the remaining four transects. Along each transect details of the substrate and presence of any conspicuous species was recorded.

In 2006 a total of eight video transects in Area 2 (each >1 km long) were undertaken with a splashcam drop-camera (Figure 2.2). Drops occurred at approximately 80 m intervals along each transect. Along each transect details of the substrate and presence of any conspicuous species was recorded.

2.1.3 Dredge tows

In 2003 no dredge tows were conducted in Area 1. In 2006, in order to survey larger macrofauna that the grab sampler may not adequately sample, a total of 12 dredge tows were conducted by ASR in Area 2. Each tow consisted of lowering the 700 mm wide dredge to the seafloor and towing it for approximately 200 m. All species captured during each tow were removed and immediately sorted. Polychaete worms, amphipods and small gastropods and bivalves that were difficult to immediately identify in the field were preserved in 5% buffered formalin in seawater. Larger macrofauna such as bivalves, hermit crabs and starfish that could be identified, were counted and returned to the sea. Scallops (*Pecten novaezelandiae*) were counted and sized (± 1 mm). Preserved dredge tow samples were processed in the laboratory as for grab samples, as described above.

Dredge tow data were then compiled and analysed to provide a description of the macrobenthic community structure (species richness and evenness).

2.2 <u>Post Sand Extraction Surveys</u>

2.2.1 2011 post sand extraction surveys

In 2011, after the extraction of 500,000 m^3, condition 14 (ii) of the consent (ARC20795) was triggered resulting in the collection of grain size data.

14. *Upon the cumulative extraction of 500,000 m^3, 1,000,000 m^3, 1,500,000 m^3 and 2,000,000 m^3 of sand, the Consent Holder shall provide to the Director an Environmental Impact Assessment of sand extraction operations up to that point in time. This shall include:*
    - *(i) an analysis of the results of the monitoring programmes required by any approved EMMP's previously submitted to the Director to ascertain whether the extraction activity has adversely affected sediment transport processes or impacted on benthic macro fauna beyond impacts experienced as a result of natural perturbations;*
    - *(ii) a comparative analysis of sediment texture at sites within and adjacent to dredged areas;*
    - *(iii) an assessment of the sea floor sediment budget from water and current processes or from other relevant studies or data for the purpose of further understanding the sea floor environment.*

2.2.1.1 <u>Grab samples</u>

In 2011 grab samples for grain size analysis were collected by Bioresearches from all 165 sites previously sampled in 2003 and 2006 in and around Area 1 and Area 2 with the exception of 4 sites which were in very close proximity to other sites. In addition, a total of 25 grab samples for grain size analysis and benthic biota were collected from a Control Area to the south of Area 1 (Figure 2.3). Samples were collected with a Standard Ponar Grab sampler, with a sample area of 229 x 229 mm, and a bite depth of about 100 mm, producing sample volumes of 1 - 4 L. A 200 ml subsample of sediment was collected from each grab sample for grain size analysis.

Grab samples from the Control Area were sieved using 1.0 mm mesh and all living organisms were preserved in 5% buffered formalin in seawater. In the laboratory, samples were rinsed through a 0.5 mm sieve and allowed to de-gas overnight. Specimens were then identified to the lowest taxonomic group possible, and then stored in 70% ethanol. Only animals with heads intact were counted and identified.

The grab sample data were then compiled and analysed to provide a description of the macrobenthic community structure.

2.2.1.2 Video survey

In 2011 two video drop camera transects in the Control Area, were conducted perpendicular to the shore in a similar areas to the grab sample transects (Figure 2.3). Drop samples were taken at approximately 100 m intervals along the transects. Details of the substrate and presence of any conspicuous species were recorded.

2.2.1.3 Dredge tows

In 2011 in order to survey larger macrofauna that the grab sampler may not adequately sample, a total of 3 dredge tows were conducted by Bioresearches in the Control Area (Figure 2.3). Each tow consisted of lowering the 600 mm wide dredge fitted with a 35 mm mesh bag to the seafloor and towing it for approximately 250 m. All species captured during each tow were removed and immediately sorted. Polychaete worms, amphipods and small gastropods and bivalves that were difficult to immediately identify in the field were preserved in 5% buffered formalin in seawater. Larger macrofauna such as bivalves, hermit crabs and starfish that could be identified were counted and returned to the sea. Scallops (*Pecten novaezelandiae*) were counted and sized (± 1 mm). Preserved dredge tow samples were processed in the laboratory as for grab samples, as described above.

2.2.2 2017 post sand extraction surveys

The 2003 and 2006 ASR reports on benthic biota did not show a comparison of the differences in biota between the habitats identified by side scan sonar. It was only stated that there is some variation in the abundance of organisms in the different seafloor types over the entire consent region, and in Area's 1 and 2 the abundances have been found to be of a similar magnitude, with only slight variation in community structure. It is also expected that these areas of differing seabed types will vary over time depending on sediment movements and storm activity. In the absence of new side scan sonar seabed type distribution data the location of the 2017 sampling sites was designed to give even representation based on the geographic location rather than proportioned on seabed type.

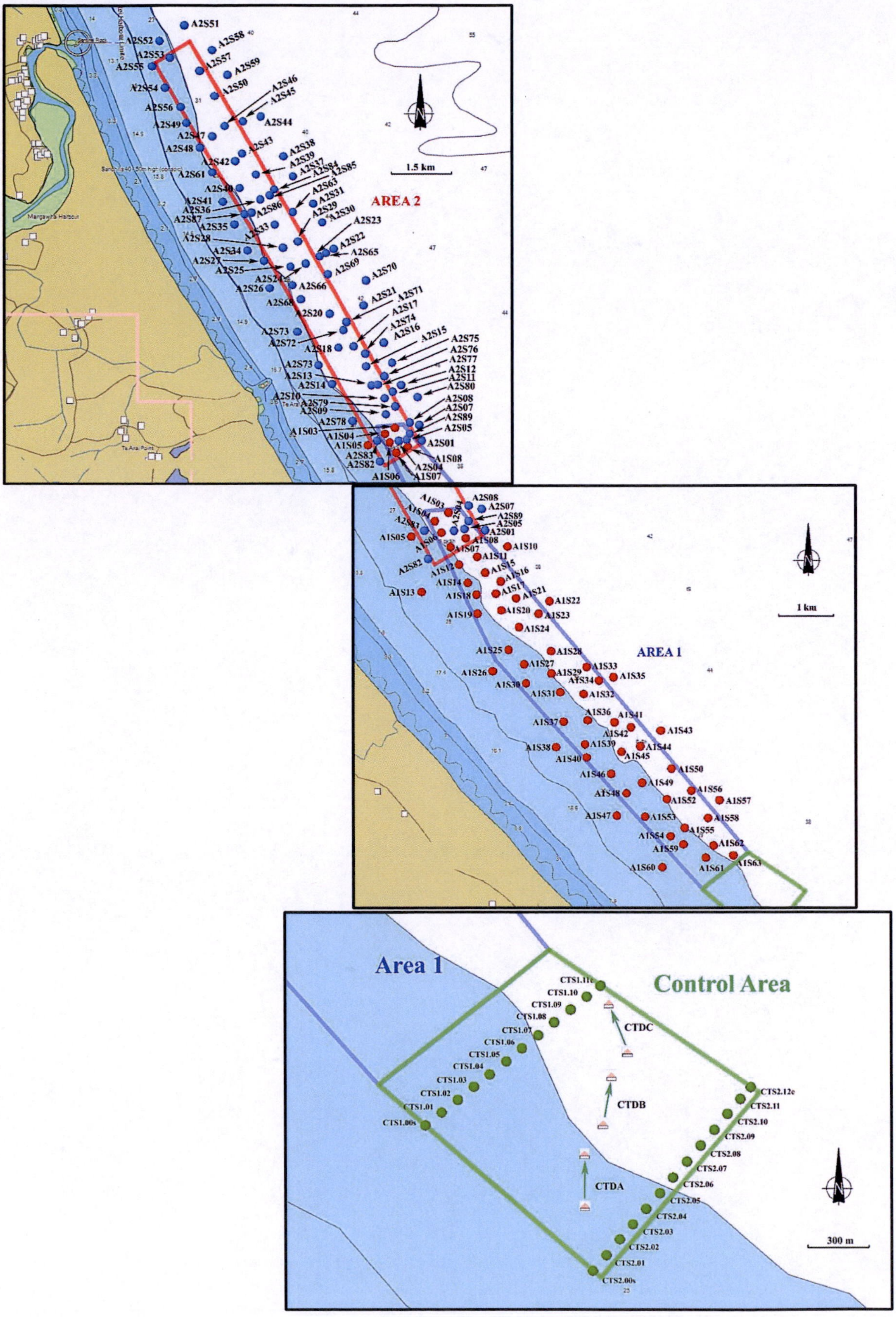

Figure 2.3 2011 Areas 1, 2 and Control sample locations (from Bioresearches, 2011)

2.2.2.1 Grab samples

A total of 74 grab samples were collected, 42 within Area 1, 13 outside Area 1 (by a maximum distance of 300 m) and 19 within the Control Area to the south, as reference sites (Figure 2.4). Samples were collected with a Standard Ponar Grab sampler, with a sample area of 229 x 229 mm, and a bite depth of about 100 mm, producing sample volumes of 1 - 4 L. If sample volume was less than 2 L the grab sample was discarded and repeated. A 200 ml subsample of sediment was collected from each grab sample for grain size analysis.

2.2.2.2 Video survey

In 2017 single drop camera samples, which included vertical images of 1 m^2 of the seabed with a compass reference, and two opposite facing lateral images of the wider adjacent seabed habitat, were conducted at each of the grab sample sites (Figure 2.4). The cameras were set to record images at 2 second intervals and the best images selected. Details of the substrate and presence of any conspicuous species were recorded.

2.2.2.3 Dredge tows

In 2017, in order to survey larger macrofauna that the grab sampler and photography may not adequately sample, a total of 15 dredge tows were conducted within Area 1 and three within the Control Area (Figure 2.4).

Each tow consisted of lowering the 600 mm wide dredge fitted with a 35 mm mesh bag, to the seafloor and towing it for approximately 100 m in an along shore direction. All species captured during each tow were removed and immediately sorted. Polychaete worms, amphipods and small gastropods and bivalves that were difficult to immediately identify in the field were preserved in 5% buffered formalin in seawater. Larger macrofauna such as bivalves, hermit crabs and starfish, which could be identified were photographed counted, measured and returned to the sea. Preserved dredge tow samples were processed in the laboratory as for grab samples, as described above.

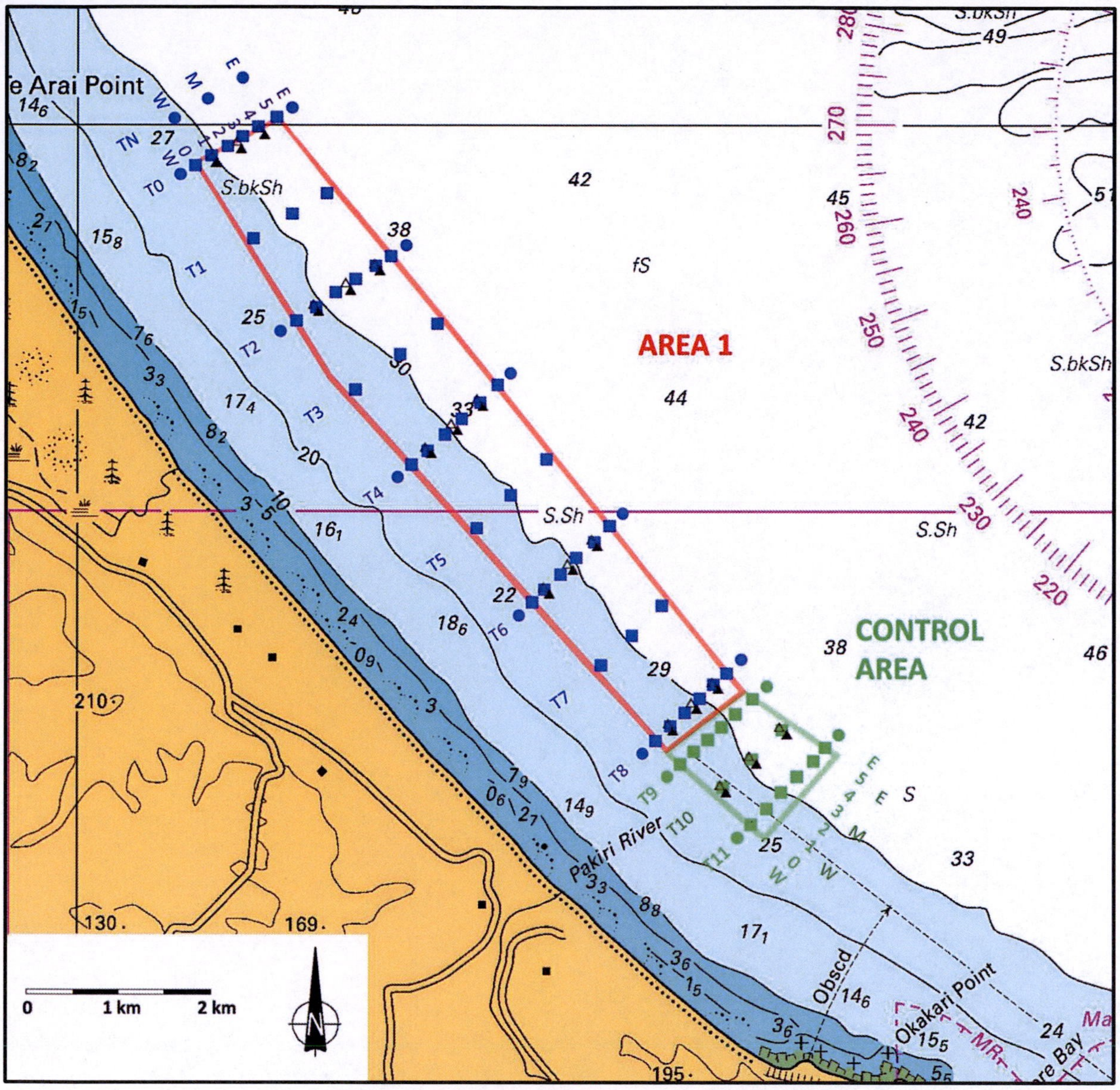

Figure 2.4 2017 Area 1 and Control Area sample locations

3. RESULTS

3.1 Grab Sample Grain Size

The 2017 grain size samples were analysed by the University of Waikato's Malvern Master sizer Laser Diffraction Particle Size Analyser. With the addition of manual volumetric and weight analysis of particles larger than 2 mm. The resulting percentage composition was therefore largely based on the volume of particles.

Baseline grain size data for each of the 65 Area 1 sites sampled in 2003 are summarized in Table 15 of Appendix 2. Baseline grain size data for each of the 91 Area 2 sites sampled in 2006 were not available. Grain size data for each of the 59 Area 1, 79 Area 2 and 25 Control Area sites sampled in 2011 are summarized in Table 16 of Appendix 2. Grain size data for each of the 55 Area 1 sites and 19 Control Area sites sampled in 2017 are summarized in Table 17 of Appendix 2.

The raw grain size data has been divided into the following standard size fractions.

Grain size (mm)	Class
> 3.35	Gravel
3.35 - 2.00	Granules
2.00 - 1.18	Very Coarse Sand
1.18 - 0.600	Coarse Sand
0.600 - 0.300	Medium Sand
0.300 - 0.150	Fine Sand
0.150 - 0.063	Very Fine Sand
0.063 - 0.0039	Silt
< 0.0039	Clay

According to the methodology defined in Folk (1980) the sediments were assigned a description based on the principle grain size fraction with modifiers based on the next important grain sizes. These descriptions are given as letter codes. For example, a sample which consisted of mostly sand with a significant proportion of silt and clay would be described as muddy sand. This would be denoted **mS**. If the sample had a gravel component it would be described as slightly gravelly muddy sand. This would be denoted **(g)mS**. The descriptions of the sediments are based on criteria illustrated in Figure 3.1.

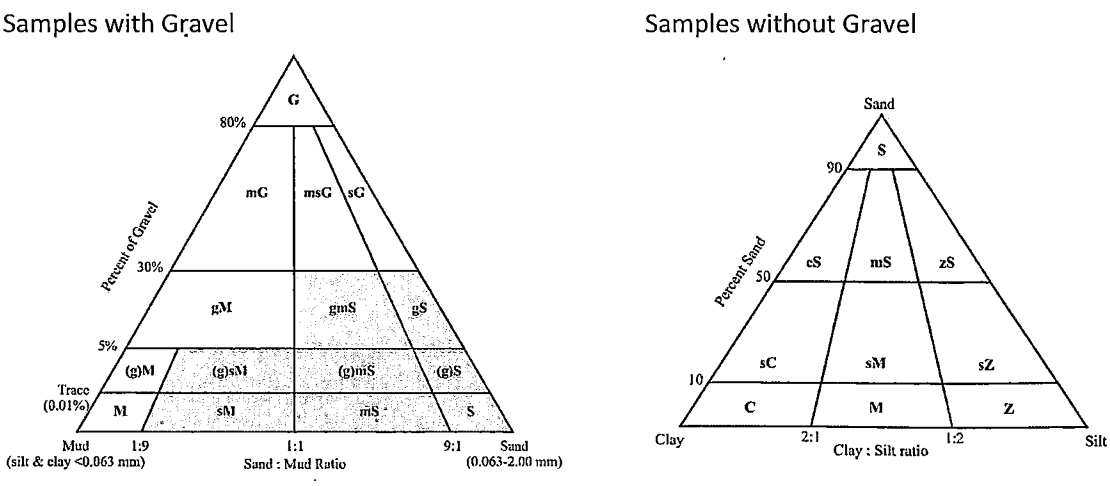

Figure 3.1 Sediment Grain Size Description. *(C=clay, M=mud, Z=silt, S=sand, G=gravel)*

3.2 Drop Camera Survey

Drop camera images and video were not available for studies conducted in Area 1 in 2003 and in Area 2 in 2006. A selected image from the drop camera videos from each of the control site drop camera sites in 2011 are presented Figure 7.1 and Figure 7.2 in Appendix 3. A selected image from each camera from each site, with additional images of any fish observed in 2017, are presented figures Figure 7.3 to Figure 7.15 in Appendix 4. The second "right" lateral image camera was damaged at the beginning of the sampling day. As a result, only the left and down images were recorded.

General summary descriptions of the video or drop camera transects are presented in Table 18 in Appendix 4 for Area 1 in 2003, and in Table 19 in Appendix 4 for Area 2 in 2006. A summary of the seabed conditions observed in the photographs from 2011 at each site are presented in Table 20 in Appendix 4. Similarly, a summary of the seabed conditions observed in the photographs from 2017 at each site are presented in Table 21 in Appendix 4.

3.3 Grab Sample Benthic Biota

Detailed site specific baseline benthic biota data for Area 1 in 2003 and Area 2 in 2006 were not available. However, total numbers of individuals per survey for each species/taxa recorded are presented in Table 22 for Area 1 in 2003 and Table 23 for Area 2 in 2006, both in Appendix 4. Detailed site specific baseline benthic biota data for the Control Area in 2011 are presented as Table 25 in Appendix 4.

Detailed benthic biota data for each site sampled in 2017 in Area 1 and the Control Area following sand extraction are presented as Table 27, Table 28 and Table 29 in Appendix 4.

3.4 Dredge Tow Macrobenthic Biota

No baseline dredge tow data was collected for Area 1 in 2003. Detailed baseline dredge tow data from each dredge tow in Area 2 in 2006 were not available. However total numbers of individuals for the survey for each species/taxa are presented as Table 24 for Area 2 in 2006 in Appendix 4. Detailed site specific baseline dredge tow data for the Control Area in 2011 are presented as Table 26 in Appendix 4.

The detailed dredge tow data, including sizes of shellfish and densities per 100 m^2, are presented in Table 30 in Appendix 4.

4. DISCUSSION

To establish if there has been any quantifiable effects between before, during and after the extraction of sand from the area, data collected in the 2003, 2006, 2011 and 2017 studies have been standardised and divided into areas to allow comparison. The southern Area 1 was chosen for reassessment of sediment grain size and benthic biota in 2017 as this area has had the most sand extracted from it in recent years, making the detection of an extraction effect more likely than for the northern Area 2. All studies have shown there is a gradient of habitat types from inshore to offshore largely related to sediment type and depth (ASR 2003, ASR 2006, Bioresearches 2011a, Bioresearches 2011b, and Bioresearches 2016). Therefore the sample sites from Area 1 have been divided into a number of groupings to determine effects based on depth

- Inshore of the Area 1 boundary
- Within Area 1, but less than 30m depth
- Within Area 1, but greater than 30m depth
- Offshore of the Area 1 boundary

These groupings have further been divided into "north" and "south" to determine any differences along shore. Similar depth groupings have also been applied to the Control Area sample sites. To compare differences over time, sample sites from each sampling time have been assigned to one of these areas to form a matrix with which summary statistics can be made and statistically compared.

4.1 Seabed Morphology

Table 1 summarises the seabed conditions mostly found within each area and depth segment for each survey. The descriptive nature of the data precludes statistical analysis. In general the seabed micro topography and condition shows a pattern that varies with increased depth and distance from shore, of;

- fine sand with irregular small or no ripples inshore of the sand extraction areas,
- increasing sand size and ripple size with depth, across the sand extraction area,
- larger ripples with shell lag in the offshore section of the sand extraction area,
- back to longer period low ripples in deeper water beyond the sand extraction area.

The initial side scan sonar studies (Figure 4.1 and Figure 4.2) identified that the seabed was divided into four different seabed type zones in bands parallel to shore. Along shore from the Control area to Area 2 there seabed is relatively similar being mostly sandy with even ripples with shell lag in between.

Table 1 Summary of Seabed conditions

Depth group	Survey	Area 2	Area 1 North	Area 1 South	Control
Inshore	2003	-	Finer sand small less regular ripples.	Fine flat sand, worm casts	-
	2006	Irregular sand ripples shell lag. Scallops	Irregular sand ripples shell lag and bioturbation. Scallops	-	-
	2011	-	-	-	-
	2017	Irregular small sand ripples shell lag.	Sand 95%, fine and coarse shell debris 4%. Uneven ripples.	Sand 65%, fine and coarse shell debris 21%. Uneven ripples.	Sand 92%, fine and coarse shell debris 6%. Uneven ripples. Scallops
<30m	2003	Finer sand less regular ripples. Horse mussels	Finer sand less regular ripples. Horse mussels	Finer sand less regular ripples.	-
	2006	Smaller ripples and finer sand than offshore with shell lag. Scallops	Irregular sand ripples shell lag and bioturbation. Scallops	-	-
	2011	-	-	-	Large sandy ripples with shell lag in the north and smaller sandy ripples with mud in south. Bioturbation and starfish present.
	2017	Small sandy ripples with shell lag. Scallops	Sand 73%, fine and coarse shell debris 25%. No ripples in shallow size increases with depth. Scallops and fish	Sand 54%, fine and coarse shell debris 35%. No ripples in shallow size increases with depth. Scallops and fish	Sand 75%, fine and coarse shell debris 23%. Medium ripples. Scallops
>30m	2003	Large regular coarse sand ripples with shell lag. Horse mussels	Large regular coarse sand ripples with shell lag. Horse mussels	Large regular coarse sand ripples with shell lag. Horse mussels	-
	2006	Regular large sandy ripples. Scallops	Irregular sand ripples shell lag and bioturbation. Scallops	-	-
	2011	-	-	-	Sandy with patches of mud, some shell lag in larger ripple but ripples decreasing with increasing depth.
	2017	Regular medium sandy ripples with shell lag. Scallops and sponges	Sand 81%, fine and coarse shell debris 15%. Medium to large ripples.	Sand 68%, fine and coarse shell debris 27%. Medium ripples in shallow decreases with depth.	Sand 73%, fine and coarse shell debris 24%. Uneven ripples. Scallops
Offshore	2003	-	Coarse large sandy ripples.	Large regular coarse sand ripples with shell lag. Horse mussels	-
	2006	Regular large sandy ripples. Blue cod, Scallops	Irregular sand ripples shell lag and bioturbation	-	-
	2011	-	-	-	-
	2017	Regular medium sandy ripples with shell lag.	Sand 75%, fine and coarse shell debris 23%. Medium to large ripples.	Sand 86%, fine and coarse shell debris 8%. Uneven ripples.	Sand 60%, fine and coarse shell debris 39%. Uneven ripples. Scallops

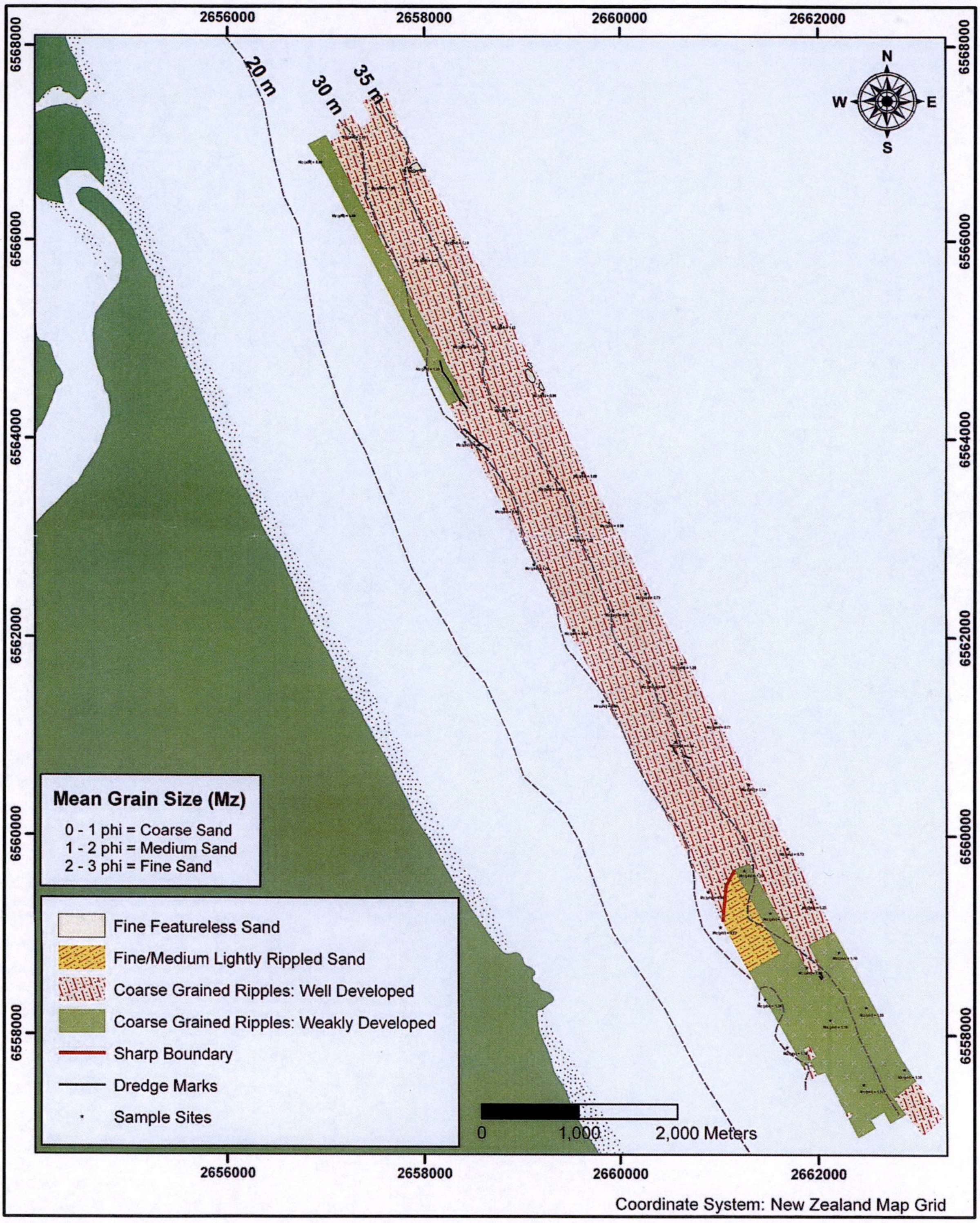

Figure 4.1 Estimated distribution of four seafloor types in Area 2 from 2006 side scan sonar results.

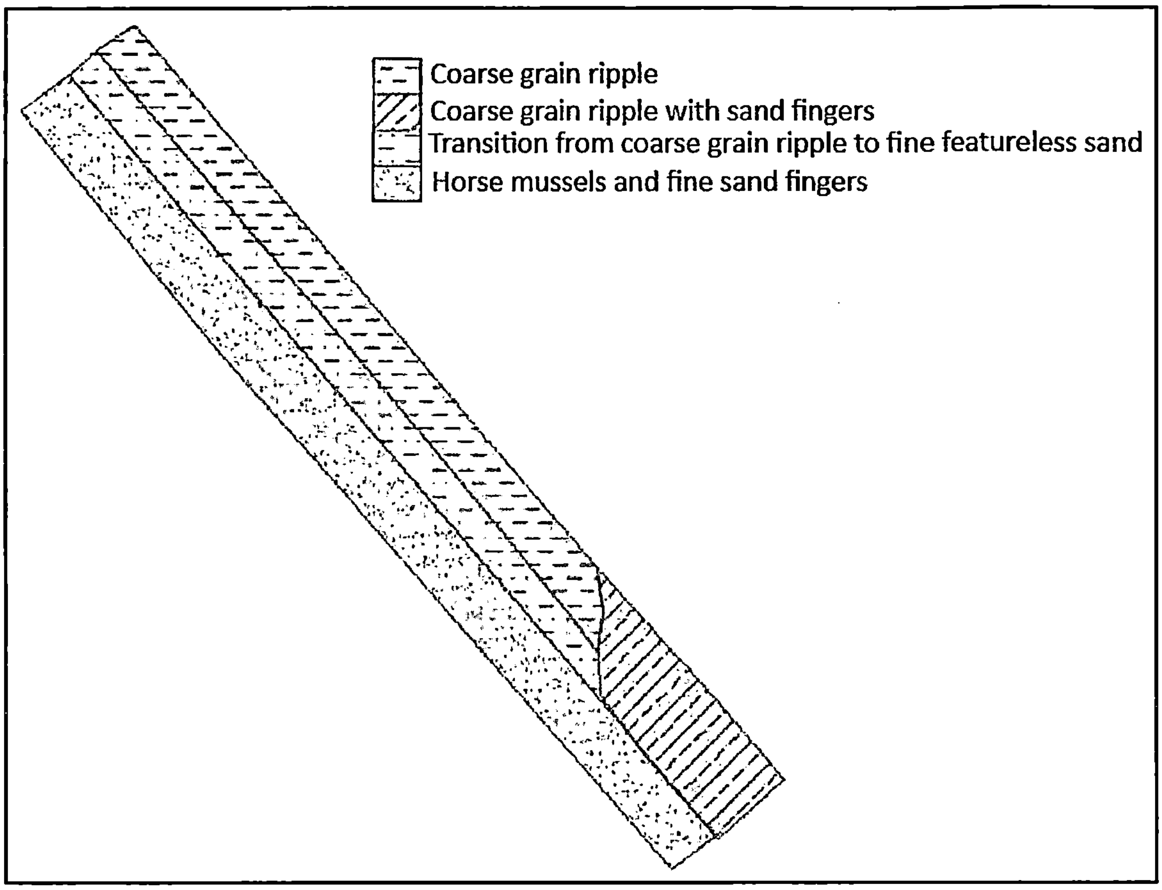

Figure 4.2 Estimated distribution of four seafloor types in Area 1 from 2003 side scan sonar results.

Several differences are apparent in the data. Horse mussels (*Atrina zelandica*) were present on the seabed during the 2003 survey of Area 1, but absent from subsequent surveys. *A. zelandica* are sensitive to small increases in suspended sediment concentrations, even for short term periods (less than 3 day periods) such as storm events (Ellis *et al.*, 2002). The disturbance of the seabed by dredging is likely to have increased the suspended solids concentrations in and around the area. This, combined with the seabed disturbance in the sand extraction areas, is the likely the cause of the lack of *A. zelandica* in later surveys.

Scallops (*Pecten novaezelandiae*) were notably not recorded in studies undertaken in 2003, but were present in 2006 and subsequently in 2011 and 2017. Scallops and other shellfish populations have been subject to mass mortality events in northern New Zealand (Morrison, 1999). Following these events they are able to recolonise areas via larval dispersion and settlement and have a relatively fast growth rate, reaching adult sizes in approximately three years. Scallops are highly mobile and have the ability to move, or "swim", significant distances. Thus it is possible that a mortality event occurred prior to the 2003 sampling or that a storm event caused them to move, but they have recovered in the subsequent years.

On comparison of the Area 1 seabed types over time, little change in seabed types could be determined prior to sand extraction when compared to during and post sand extraction. It is expected that seabed ripple patterns are largely defined by weather and wave patterns in combination with seabed depth.. Since the seabed depth has not changed significantly as a result of sand extraction the lack of change in seabed types is not unexpected. The changes in obvious benthic macrofauna is largely as expected. Improvements in the sampling techniques and technology used has resulted in better documentation of seabed conditions over time. Poor documentation of baseline conditions in 2003 and 2006 has limited the comparison with later studies.

4.2 Seabed Grain Size

In 2003 grain size samples were analysed for texture in the Rapid Sediment Analyser fall tube system at the University of Waikato, resulting in a percentage composition by weight. This was repeated for the 2006 Area 2 grain size samples, however the raw data were not available. The 2011 and 2017 grain size samples were analysed by the University of Waikato's Malvern Master Sizer Laser Diffraction Particle Size Analyser. With the addition of manual volumetric and weight analysis of particles larger than 2 mm. The resulting percentage composition was therefore largely by volume not weight based as per the 2003 and 2006 samples.

The differences in parameter measured (weight or volume) to quantify the grain size class have largely been ignored as the 2003 weight based data cannot be converted to the volume based data collected in 2011 and 2017. This would necessitate the use of many unsupported assumptions, such as homogenous particle density and homogenous spherical shaped particles, to convert the volume based 2011 and 2017 data to match the weight based data from 2003 and 2006. The volume based assessment is inducted as required by the consent (ARC 20795) condition 10A(i) which specifies the sediment is not to have more than 20% by volume of particles smaller than 0.063 mm.

Grain size data for each of the 66 Area 1 sites sampled in 2003 are summarized in Table 15 of Appendix 2. The grain size data for each of the 59 Area 1 sites, 79 Area 2 sites and 25 Control Area sites sampled in 2011 are summarized in Table 16 of Appendix 2. The grain size data for each of the 55 Area 1 sites and 19 Control Area sites sampled in 2017 are summarized in Table 17 of Appendix 2. The data in the tables in Appendix 2 are colour coded by area with Area 2 (blue), Area 1 North (purple), Area 1 South (red) and Control (green). Which sites belong to which group are identified in Table 5, Table 10 and Table 13 in Appendix 1, and are similarly coloured.

The average percentage of each size class from each sample event has been calculated for the Area 1 North, Area 1 South and Control site which have then been divided into **inshore** of the sand extraction area boundary, **<30 m** depth inside the sand extraction area, **>30 m** depth inside the sand extraction area and **offshore** of the sand extraction area boundary for each of the sand extraction areas as described above, and are presented in Table 2.

When the mean grain size data in Table 2 are shown graphically (Figure 4.3) it can be seen that there are differences across the sand extraction area from shallow to deeper, particularly in the northern part of Area 1. These difference are statistically significant at less than the P=0.05 level, but the differences vary between years. No conclusions can be drawn by differences between the 2003 and 2011, or between the 2003 and 2017 data, as the 2003 data is based on weight and the 2001 and 2017 are based on volume. The difference across the sand extraction area in the Area 1 South and Control areas are less pronounced, not statistically significant, and in some cases differ from those observed in Area 1 North. In general, grain size increases statistically significantly with depth in the north of Area 1 and is statistically similar at different depths in the south of Area 1 and in the Control Area further south. It is unclear whether the greater differences across shore between the 2003 and later surveys seen in the mean grain size in Area 1 North are related to sand extraction activity because the initial 2003 control data is lacking and because of the differences in the method of measurement between the 2003 survey and the later surveys. This is also the case for the grain size differences in Area 1 South between the 2003 and later surveys.

Table 2 Summary of Grain size data by time and area

Date	Area		Size class (mm)							Mean Size	Grain Size Description
			Gravel	Sand					Silt and Clay		
				Very Coarse	Coarse	Medium	Fine	Very Fine			
			> 2.00	2.00 - 1.00	1.00 - 0.50	0.50 – 0.25	0.250 – 0.125	0.1250 – 0.0625	< 0.0625	(mm)	
2003 (percentage by weight)	Area 1 North	Inshore	1.56	3.27	37.58	48.82	6.45	1.24	1.08	0.395	(g)S
		<30 m	0.53	0.28	5.40	63.22	27.65	2.45	0.46	0.237	(g)S
		> 30 m	0.62	3.23	15.80	67.06	9.81	2.74	0.74	0.346	(g)S
		Offshore	0.65	5.32	25.63	58.46	7.87	1.70	0.37	0.404	(g)S
		Dredge Area	**0.59**	**2.18**	**12.09**	**65.69**	**16.18**	**2.64**	**0.64**	**0.307**	**(g)S**
	Area 1 South	Inshore	0.33	0.98	3.70	75.17	11.79	4.69	3.34	0.256	(g)S
		<30 m	0.33	1.34	5.10	76.26	14.02	2.39	0.56	0.281	(g)S
		> 30 m	1.31	1.92	25.95	53.70	9.48	6.06	1.58	0.331	(g)S
		Offshore	1.47	0.38	34.57	11.75	43.64	8.19	0.00	0.291	(g)S
		Dredge Area	**0.78**	**1.60**	**14.58**	**66.00**	**11.96**	**4.06**	**1.02**	**0.304**	**(g)S**
	All Area 1	***Dredge Area***	***0.67***	***1.92***	***13.18***	***65.83***	***14.32***	***3.26***	***0.81***	***0.306***	***(g)S***
	Control	<30 m	0.00	2.16	3.29	82.23	5.39	5.74	1.19	0.325	S
		> 30 m	1.62	1.69	65.21	28.19	3.30	0.00	0.00	0.465	(g)S
		Control	**0.81**	**1.92**	**34.25**	**55.21**	**4.35**	**2.87**	**0.60**	**0.395**	**(g)S**
2011 (percentage by volume)	Area 1 North	Inshore	8.63	5.36	37.58	40.37	7.71	0.04	0.31	0.583	gS
		<30 m	8.91	4.14	30.44	41.34	14.06	0.43	0.66	0.525	gS
		> 30 m	6.64	10.21	45.04	33.41	4.17	0.21	0.32	0.629	gS
		Offshore	17.68	17.99	39.78	18.01	2.74	0.87	2.93	0.861	gS
		Dredge Area	**7.42**	**8.12**	**40.02**	**36.14**	**7.57**	**0.28**	**0.44**	**0.593**	**gS**
	Area 1 South	Inshore	20.64	5.39	33.19	34.59	6.19	0.00	0.00	0.808	gS
		<30 m	10.78	5.35	33.34	38.12	11.70	0.41	0.30	0.571	gS
		> 30 m	9.14	13.17	37.35	28.67	10.24	1.19	0.24	0.671	gS
		Offshore	9.00	8.36	20.67	32.06	24.65	3.29	1.97	0.537	gS
		Dredge Area	**10.08**	**8.70**	**35.06**	**34.07**	**11.08**	**0.74**	**0.28**	**0.614**	**gS**
	All Area 1	***Dredge Area***	***8.47***	***8.35***	***38.06***	***35.32***	***8.96***	***0.47***	***0.37***	***0.601***	***gS***
	Control	<30 m	5.27	3.75	38.54	43.91	7.89	0.04	0.60	0.523	gS
		> 30 m	7.77	4.31	37.37	40.14	9.73	0.68	0.00	0.565	gS
		Control	**6.47**	**4.02**	**37.98**	**42.10**	**8.77**	**0.35**	**0.31**	**0.543**	**gS**
2017 (percentage by volume)	Area 1 North	Inshore	0.00	1.53	27.96	51.62	17.78	0.32	0.78	0.387	S
		<30 m	0.06	1.29	22.04	50.71	23.89	0.83	1.19	0.351	(g)S
		> 30 m	0.46	10.97	41.78	34.91	8.53	0.84	2.51	0.523	(g)S
		Offshore	1.45	19.75	45.33	23.88	6.34	0.89	2.37	0.620	(g)S
		Dredge Area	**0.31**	**7.34**	**34.38**	**40.84**	**14.29**	**0.83**	**2.01**	**0.459**	**(g)S**
	Area 1 South	Inshore	0.00	3.09	25.76	44.86	24.41	1.31	0.59	0.385	S
		<30 m	0.33	5.45	33.14	44.25	15.62	0.60	0.62	0.432	(g)S
		> 30 m	0.56	12.54	35.51	34.94	13.55	1.14	1.77	0.499	(g)S
		Offshore	0.50	0.96	8.62	44.67	39.93	3.72	1.61	0.268	(g)S
		Dredge Area	**0.43**	**8.60**	**34.19**	**40.11**	**14.70**	**0.84**	**1.13**	**0.462**	**(g)S**
	All Area 1	***Dredge Area***	***0.36***	***7.88***	***34.30***	***40.53***	***14.46***	***0.84***	***1.63***	***0.460***	***(g)S***
	Control	Inshore	0.00	0.30	30.76	54.86	13.15	0.10	0.85	0.401	S
		<30 m	0.00	3.43	38.04	47.45	10.60	0.26	0.23	0.451	S
		> 30 m	0.37	3.81	23.87	42.56	25.38	2.87	1.15	0.372	(g)S
		Offshore	0.60	10.26	24.46	32.40	26.79	3.82	1.67	0.438	(g)S
		Control	**0.20**	**3.96**	**30.62**	**44.84**	**18.02**	**1.58**	**0.78**	**0.415**	**(g)S**

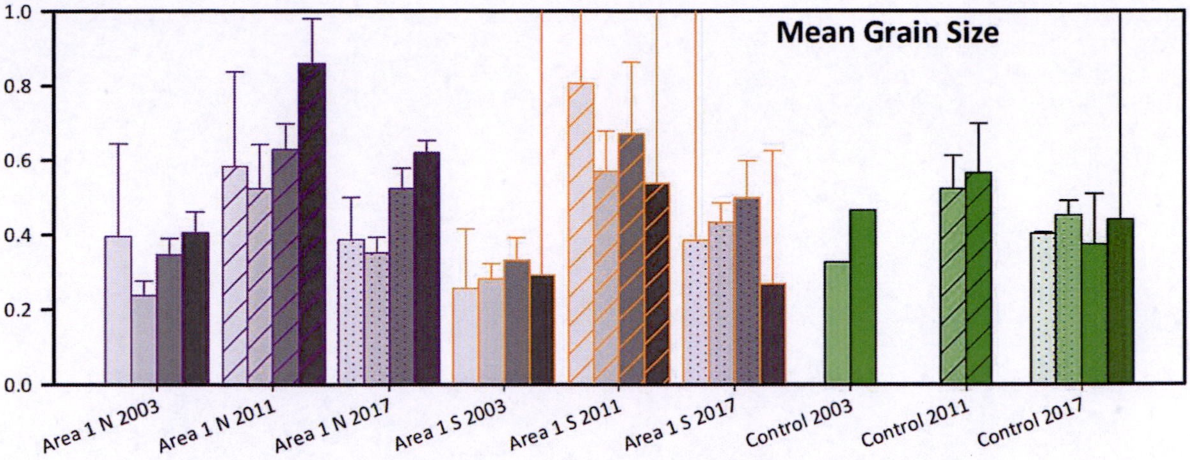

Figure 4.3 Average mean grain sizes (mm) per Area and Survey, showing changes with depth. *(Mean Grain Size ± 95% CL) (In shore, <30 m depth within, >30m depth within, Off shore, 2003 survey (weight based), // 2011 survey (volume based), 2017 survey (volume based) as shown in Table 2)*

The graphical presentation of the changes in proportions of the individual size groupings (Figure 4.4) shows size groupings largely responsible for the mean size changes were gravel, coarse sand and fine sand.

To assess for the effects of seabed sand extraction on the physical characteristics of the sand extraction area, the average mean grain sizes and average percentages of each grain size class have been plotted in Figure 4.5, grouped by area and showing the differences over time. Due to the differences in measurement methodology the data available from 2003 is not directly comparable with the 2001 and 2017 data so changes over time should be interpreted with caution. Visually in Figure 4.5, the mean grain size varies over time in a similar pattern in the Area 1 after sand extraction and the Control Area with no sand extraction, with increases in mean grain size from 2003 to 2011, 2003 to 2017 and decreases from 2011 to 2017. Note the 2003 Control area average mean grain size is based on two samples and shows a much higher degree of variability than other site and time combinations, as indicated by the 95% CL intervals shown in Figure 4.5. The assumptions of normality and equal variance for a parametric ANOVA testing were generally not met. This is largely due to the unbalanced statistical design of the available data and the type of data, no nonparametric tests were available. Therefore, the analysis has been based on the parametric testing and the result interpreted with caution. Statistically there was a general difference over time ($p=<0.001$) with 2011 different from the other surveys, but no general difference between Area 1 and the Control ($p=0.905$) or for either of the sampling events. Statistically the effect of different levels of area does not depend on what level of Date is present. There is not a statistically significant interaction between Date and Area. ($p = 0.384$). Therefore, the changes observed in Area 1 over time are not different to those changes observed in the Control area over time, there has not been a statistically significant measureable effect of sand extraction on the mean grain size in the sand extraction area greater or less than that observed in the control area. Similar statistical results were observed for each of the individual sediment grain size classes, there has not been a statistically significant measureable effect of sand extraction on the percentages of grain size classes in the sand extraction area greater or less than that observed in the control area.

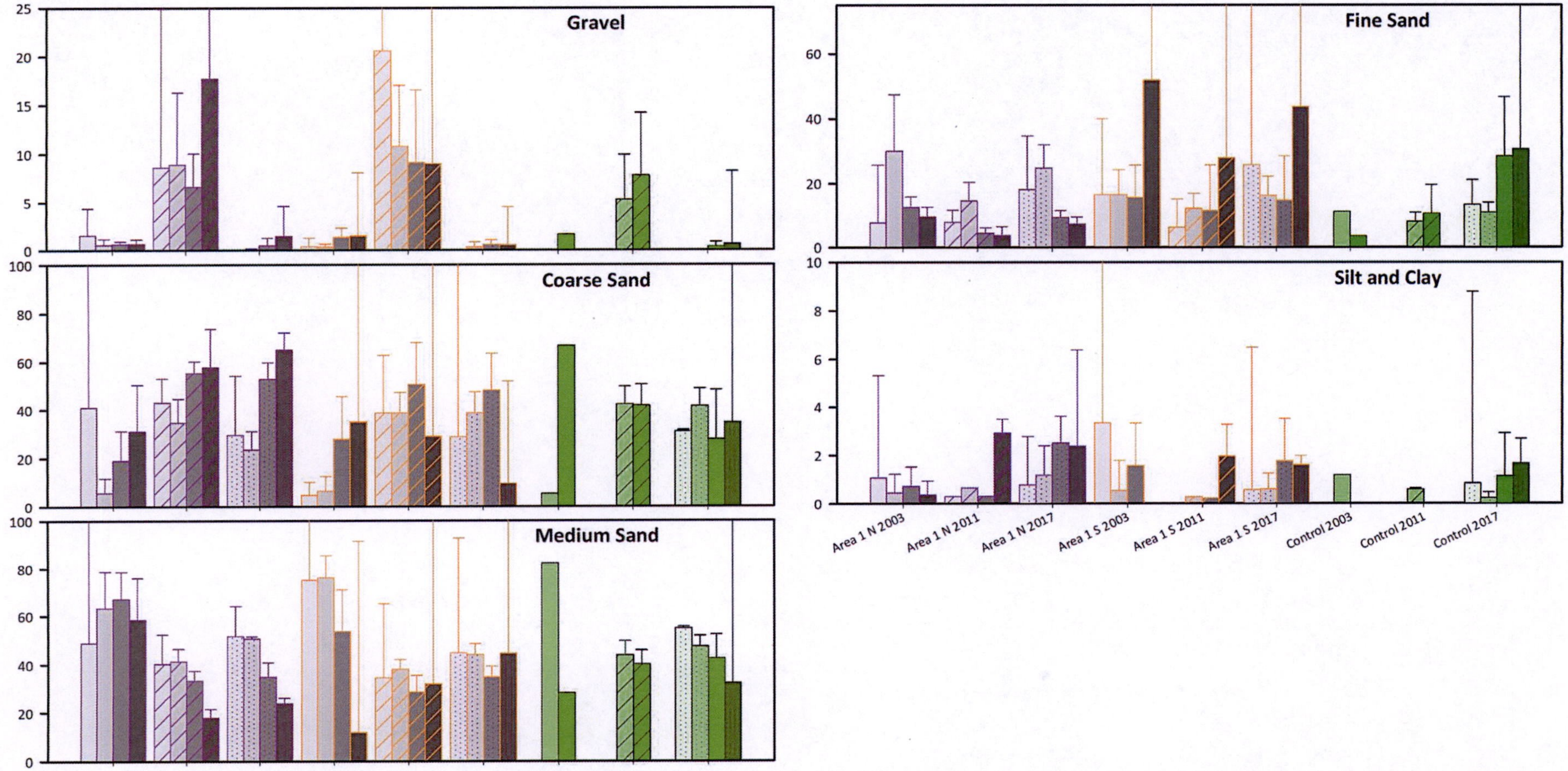

Figure 4.4 ***Proportion of size class groupings per Area and Survey, showing changes with depth.*** *(Average percentage ± 95% CL) (In shore, <30 m depth within, >30m within, Off shore, 2003 survey (weight based), // 2011 survey (volume based), 2017 survey (volume based))*

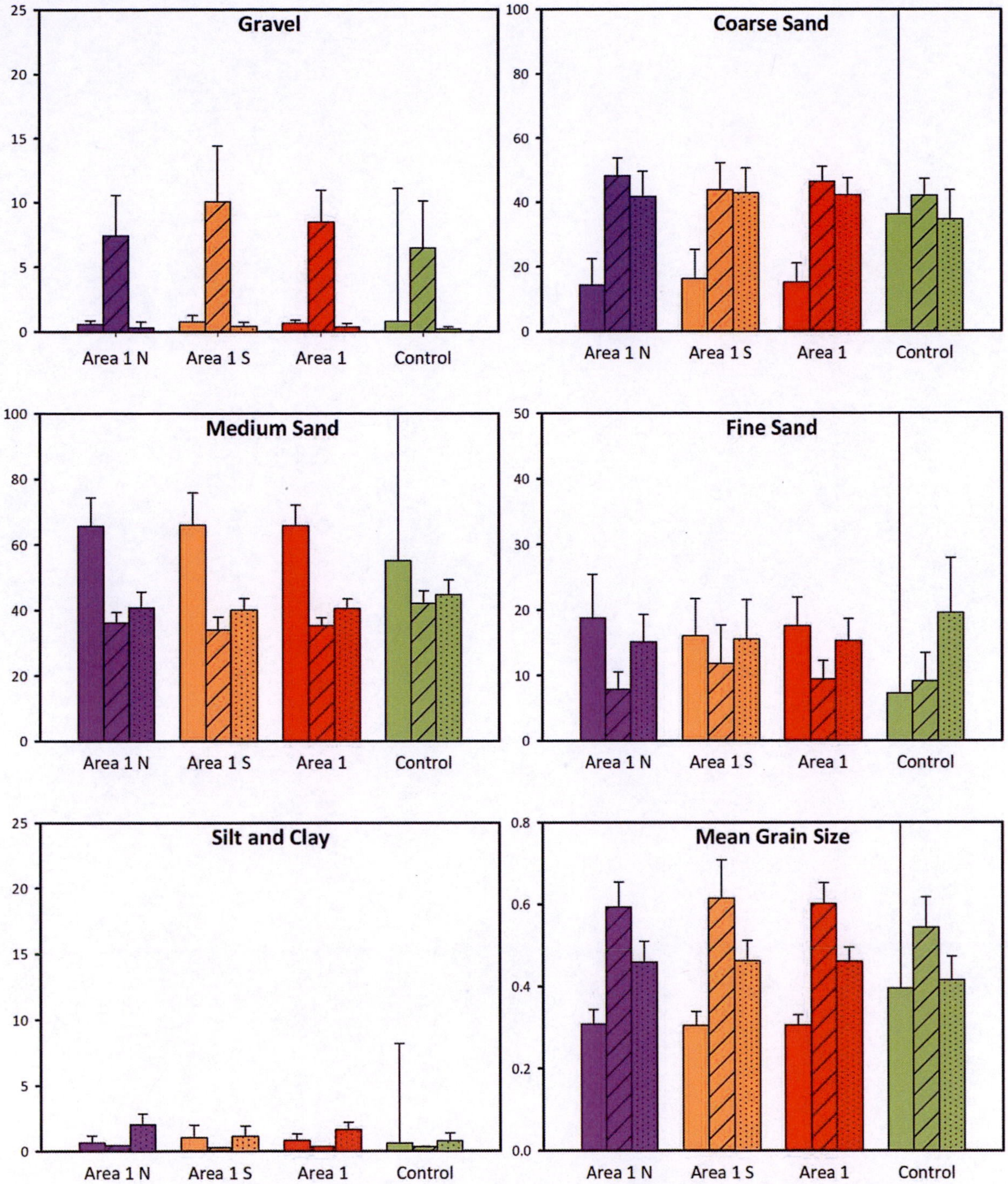

Figure 4.5 Changes in the proportion of sediment grain size class groupings over time per Area. *(Average percentage ± 95% CL) (■ Area 1 North, ■ Area 1 South, ■ All Area 1, ■ Control Area, □ 2003 survey (weight based), // 2011 survey (volume based), ░ 2017 survey (volume based))*

4.3 Benthic Biota

Surveys of the dredge area have involved numerous variations on a standard method of grab samples for random locations across the area and beyond. In 2003 a total of 65 grab samples were collected using a Smith-Macintyre grab sampler, 50 within the sand extraction area and 15 outside the area. A total of 59 different species (725 individuals) were identified from the 65 grab samples. Raw data were not presented to enable further investigation into the geographic spread of species. Amphipods and other crustacea (e.g. cumacea, shrimp, and hermit crab) dominated the samples, accounting for 62% of all individuals found. Polychaetes made up 19% of all individuals found, while bivalves accounted for 13% and low numbers of lancelets (3.1 %), gastropods (1.9%) and nematodes (1 %) made up the remainder. A single brittle star was collected. The number of individuals found in each sample ranged from 0-29, with an average of 11 per sample (Table 3). No protected or sensitive species were identified in or around the dredge area, nor were any benthic macrofauna or communities of particular conservation value or significance identified from the grab sample data.

In 2011, 25 grab samples were collected using a Ponar grab sampler from the Control area, a total of 62 different species (496 individuals) were identified from the 25 grab samples. Polychaete worms numerically dominated the grab samples and these accounted for 51% of all individuals found. The next most numerically dominant taxa were amphipods and other crustacea (e.g. hermit crabs, shrimps) with 31%, followed by bivalves (14%) and other taxa (4%), which were largely comprised of gastropods, the lancelet *Epigonichthys hectori,* and sponges.

While polychaete worms were numerically dominant, they were not the most diverse class, they shared this with crustaceans each with 20 species, followed by bivalves (13 species), and gastropods (3 species).

In 2017 a total of 74 grab samples were collected using a Ponar grab sampler, 40 within the sand extraction Area 1 and 13 outside, plus 19 in the Control Area. A total of 184 different species (23,362 individuals) were identified from the 74 grab samples. Within the geographic area of sand extraction a total of 161 different species at a density of 6,705 individuals per m^2 were identified from the 42 grab samples. In the Control area 128 different species at a density of 4,253 individuals per m^2 were identified from the 19 grab samples.

Within the sand extraction area amphipods and other crustacea (e.g. cumacea, shrimp, and hermit crab) dominated the samples, accounting for 65% of all individuals found. Polychaetes made up 29% of all individuals found, the remainder was dominated by bivalves (1.6%), gastropods (1.2%), lancelets (0.7%) and salps (1.2%). Nematodes, echinoderms, anemones, bryozoans, sea squirts and sponges, while present, were rare. While crustaceans (in particular amphipods) were numerically dominant, they were not the most diverse taxonomic group. Forty-eight species of polychaete and 47 species of mollusc were recorded in comparison to the 43 species of crustaceans.

Within the control area the biota were numerically dominated by polychaetes accounting for 48% and by amphipods and other crustacea (e.g. cumacea, shrimp, and hermit crab) accounting for 45% of all individuals found. The remainder was dominated by bivalves (3.2%), gastropods (1.2%) and chordates (1.7%). Nematodes, echinoderms, anemones, bryozoans, sea squirts and sponges while present were not very diverse. While crustaceans and polychaetes were numerically dominant, they were not the most diverse taxonomic group, they shared this with polychaetes (38 species), crustacea (35 species) and mollusc (37 species). These three groups accounted for all but 18 species.

Table 3 Summary of Benthic Biota Data

Date	Area		Number Species per Replicate		Total Number Species per Station	Number Individuals per Replicate		Shannon - Wiener Diversity Index	
			Average	95% CL		Average	95% CL	Average	95% CL
2003	Area 1 North	Inshore							
		<30 m							
		> 30 m							
		Offshore							
		Dredge Area							
	Area 1 South	Inshore							
		<30 m							
		> 30 m							
		Offshore							
		Dredge Area							
	All Area 1	***Dredge Area***			***59***	***11***	***6***	***2.9***	
	Control	<30 m							
		> 30 m							
		Control							
2011	Area 1 North	Inshore							
		<30 m							
		> 30 m							
		Offshore							
		Dredge Area							
	Area 1 South	Inshore							
		<30 m							
		> 30 m							
		Offshore							
		Dredge Area							
	All Area 1	***Dredge Area***							
	Control	<30 m	8.69	2.25	45	21.08	7.65	1.76	0.26
		> 30 m	9.00	2.35	47	18.50	8.22	1.81	0.30
		Control	**8.84**	**1.50**	**62**	**19.84**	**5.19**	**1.79**	**0.18**
2017	Area 1 North	Inshore	35.00	11.38	65	316.33	479.10	2.45	0.83
		<30 m	45.89	8.82	111	775.89	395.50	2.18	0.25
		> 30 m	34.20	4.66	116	191.13	76.54	2.59	0.15
		Offshore	29.33	29.64	57	190.33	526.57	2.38	0.47
		Dredge Area	**38.58**	**4.67**	**138**	**410.42**	**182.77**	**2.44**	**0.15**
	Area 1 South	Inshore	42.00	12.71	60	401.50	3513.27	2.89	6.13
		<30 m	35.50	7.97	95	260.60	169.30	2.67	0.24
		> 30 m	32.75	12.10	102	289.00	189.94	2.07	0.39
		Offshore	38.50	82.59	51	571.00	546.37	2.07	1.09
		Dredge Area	**34.28**	**6.17**	**120**	**273.22**	**112.43**	**2.40**	**0.25**
	All Area 1	***Dredge Area***	***36.74***	***3.65***	***161***	***351.62***	***112.79***	***2.42***	***0.13***
	Control	Inshore	36.00	63.53	54	348.50	247.77	2.44	2.32
		<30 m	27.75	8.07	83	153.13	133.43	2.73	0.27
		> 30 m	34.75	9.18	100	277.50	144.23	2.33	0.30
		Offshore	23.00	0.00	23	502.00	0.00	2.53	0.00
		Control	**31.32**	**4.89**	**128**	**223.05**	**80.16**	**2.51**	**0.17**

In 2017 two samples recorded the presence of Scleractinia, or Stony Corals. One sample in the sand extraction area (T7-E) contained 15 individuals and one sample in the control area (T10-3) contained 1 individual. During 2010, an amendment of Schedule 7A of the Wildlife Act (1953) widened the range of corals afforded protection to include "all deepwater hard corals (all species in the orders Antipatharia, Gorgonacea, Scleractinia, and Family Stylasteridae)". Therefore Scleractinia are protected under the Wildlife Act (1953). Scleractinia are more abundant in deeper waters. Samples collected at Mangawhai to the north of the sand extraction area did not record their presence until 60 m depth. The sample site T7-E is located approximately 88 m inside the sand extraction area on the south eastern side, in a depth of approximately 35 m. This is relatively shallow for Scleractinia which have a normal habitat range from 50 m to significantly deeper depths. Scleractinia were not previously recorded in either the sand extraction area or the control area in 2003, 2006 or 2011.

The 2003 ecological survey of Area 1 reports did not provide any detail on the size of the grab sampler, other than it had a bite depth of 10 cm and bite volume of 2 L. Therefore the data could not be normalized to number per area. In 2011 and 2017 a standard Ponar grab sampler was used with a sample area of 22.9 x 22.9 cm, with a bite depth of about 10 cm. The 2003 and 2011 samples were sieved wet though a 1 mm mesh sieve and all living organisms retained, however, in 2017 samples were sieved wet though a 0.5 mm mesh sieve. The variation in sample type and sieve size used has result in data that differs across time that cannot be compared numerically across time, however, nonparametric comparisons of species percentages are possible. In addition the ability to identify biota to species level has changed over time, thus higher taxonomic grouping is required to make the data comparable.

At the Control site the abundance and diversity of taxa has changed between 2011 and 2017 (Figure 4.6). The percentage abundance of crustacea and gastropods has increased statistically significantly between 2011 and 2017, while the percentage abundance of bivalves has decreased statistically significantly. At the same time the percentage diversity of gastropods has increased statistically significantly while the percentage diversity of polychaetes and bivalves has decreased statistically significantly.

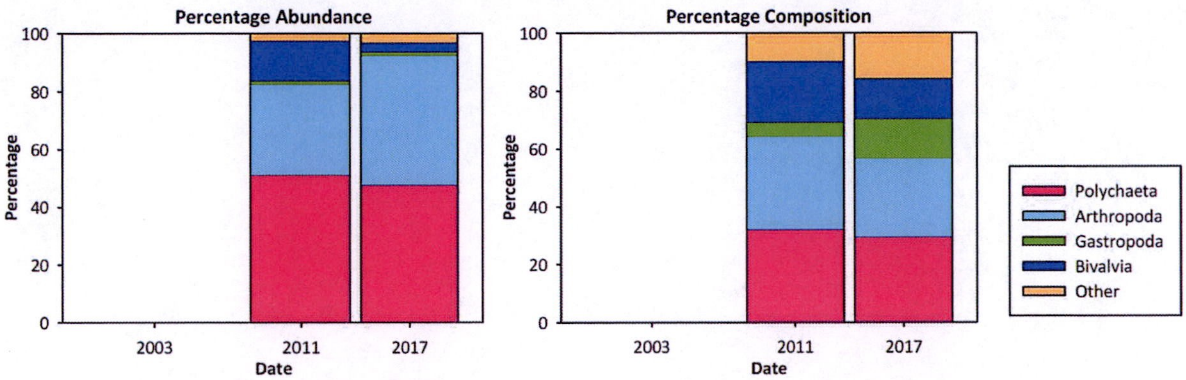

Figure 4.6 Changes in percentage abundance (by number of individuals) and percentage composition (by number of species/taxa) of benthic biota populations over time recorded at the Control site.

In the sand extraction Area the abundance and diversity of taxa has changed between 2003 and 2017 (Figure 4.7). The percentage abundance of molluscs, in particular bivalves, has decreased, while the percentage abundance of polychaetes has increased. At the same time the percentage diversity of polychaetes and bivalves has decreased while the percentage diversity of crustacea has increased. Statistical testing was not possible due to the unavailability of sample specific data from 2003.

In 2017 the percentage abundance of taxa was different between the Control and sand extraction areas while the percentage diversity was very similar (Figure 4.8). The percentage abundance of polychaetes was statistically significantly greater in the Control area when compared with the sand extraction area, while the percentage abundance of crustacea was statistically significantly greater in the sand extraction area when compared with the Control area. At the same time the percentage diversity of polychaetes, crustacea and molluscs did not vary greatly.

The increases in percentage abundance of crustacea and decreases in percentage abundance of bivalves recorded over time in the sand extraction area were similarly recorded in the Control area suggesting these changes were natural. The increases in the percentage abundance of polychaetes in the sand extraction area were greater than those recorded in the Control area, however, due to the lack replicated data from 2003 and differing sampling methods, it is not possible to statistically conclude that this is an effect of sand extraction activity. The decreased percentage abundance of bivalves in the sand extraction area is reversed in the Control area suggesting the decreased abundance of bivalves in the sand extraction area could be a sand extraction related effect. This is not an unexpected result as the disturbance of larger bivalves by dredging could easily result in lower numbers in the sand extraction area.

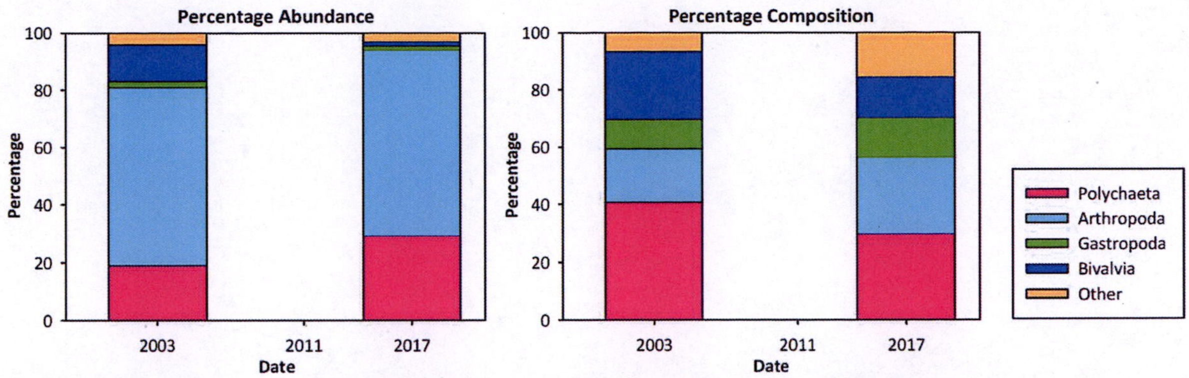

Figure 4.7 Changes in percentage abundance (by number of individuals) and percentage composition (by number of species/taxa) of benthic biota populations over time recorded in the sand extraction Area 1.

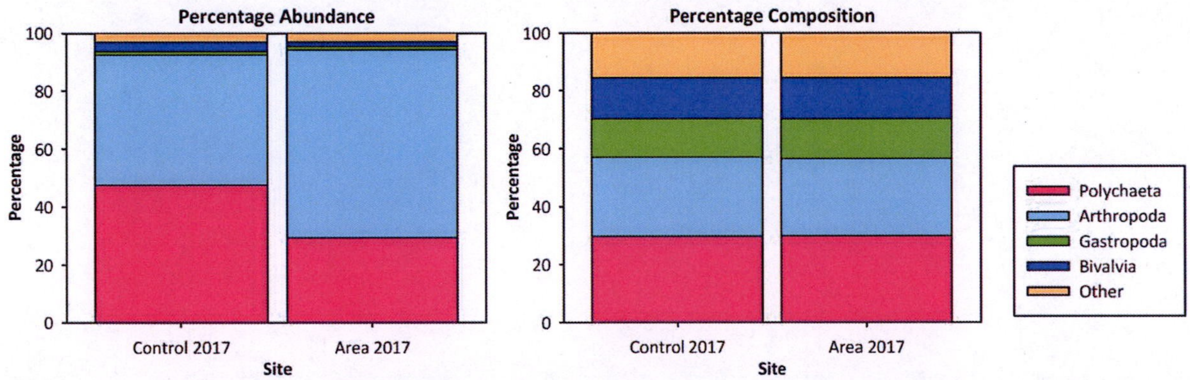

Figure 4.8 Differences in percentage abundance (by number of individuals) and percentage composition (by number of species/taxa) of benthic biota populations between the Control area and the sand extraction Area 1.

Dredging is done with a trailing suction dredger which entrains a sand/water mixture that is pumped over 2.0 mm mesh screens contained in flume pipes. All oversize material from the screens is returned to the seabed over the side. Larger biota is eventually returned to sea but will have suffered a small amount stress during the entrainment and screening process and will also be exposed to predation during its fall to the seabed. The stony corals found during this survey were larger than 2 mm so thus they would not pass through the screen into the barge and will be returned to the seabed via the overflow. Given that stony corals were not initially found in 2003, 2006 and 2011 the operation of the dredge has not prevented their establishment and survival, suggesting the dredging has limited if any, negative impact on their survival. Target material in the form of a sand slurry drops through the screens into the barge hopper. The sand settles out of the water which will pass out of the hopper over weir boards as the hopper fills. Larger sand particles will settle out faster than smaller silt and clay sized particles, which remain in suspension and are discharged to sea from the vessel. Depending on the percentage of fine material entrained this can result in a visible plume of turbid water. Since some species of biota are sensitive to increased turbidity this can also have an impact on the biota composition found on the seabed.

4.4 Macrobenthic Biota

No dredge tows were conducted in Area 1 in 2003. In 2006, 12 dredge tows were conducted in Area 2. A total of 35 different species (595 individuals) were identified (Table 24). Crustaceans and bivalves were proportionally dominant in the samples followed by gastropods and polychaetes, New Zealand lancets and brittle stars. The proportion of different taxa from the dredge tows compared to the grab samples were similar for crustaceans, however, the proportion of bivalves (predominantly scallops) were considerably higher and polychaete worms much lower in the dredge tows than for the grab samples. This highlights the necessity to use a range of techniques to quantify species presence/absence and abundance when surveying soft sediment habitats. In 2011, 3 dredge tows were conducted in the Control area. A total of 7 different species (38 individuals) were identified (Table 26). Starfish and bivalves were proportionally dominant in the samples. In 2017 a total of 15 tows were conducted in Area 1 and 3 tows in the Control area. A total of 24 different species (244 individuals) were identified in Area 1 and 15 different species (54 individuals) were identified in the Control area (Table 30).

The lack of detailed methodology in the baseline studies (2003 and 2006) prevents any sensible comparison between the later studies in the sand extraction areas. This is due to lack of samples, possible differences in mesh sizes and differences in areas sampled. However, the dredge samples are useful in that they provide same data on the larger less abundant species such as the scallop (*Pecten novaezelandiae*) and starfish (*Astropecten polycanthus*), that would not normally be recorded by the grab sampling technique. The dredge tow data from the Control area in 2011 and 2017 are comparable and show a slight increase in diversity and abundance over time (Table 4).

Apart from the wide spread, patchily distributed scallops, no additional important or sensitive species were identified in the benthic macrofauna of the sand extraction Area 1 or the Control area, nor were any benthic macrofauna or communities of particular conservation value or significance identified.

Table 4 Summary of Dredge Tow Data

Date	Site	Number of species	Number of individuals
2003	**Area 1**	Not sampled	
2006	**Area 2** No site specific data	**35**	**595**
2011	Control A	4	21
	Control B	5	14
	Control C	2	2
	Control Area	**7**	**37**
2017	T0 A	2	2
	T0 B	5	15
	T0 C	3	8
	T2 A	1	1
	T2 B	4	9
	T2 C	5	5
	T4 A	3	29
	T4 B	2	5
	T4 C	8	12
	T6 A	4	66
	T6 B	6	18
	T6 C	12	34
	T8 A	4	8
	T8 B	6	19
	T8 C	3	13
	TC A	5	18
	TC B	6	24
	TC C	9	12
	Area 1	**24**	**244**
	Control Area	**15**	**54**
	All 2017	**28**	**298**

Bold numbers indicate they are total numbers per area not just individual sites

4.5 Fin Fish

Very few surveys have been undertaken in the region of the Auckland Offshore Sand Extraction Site. Lateral seabed images recorded by drop camera in 2017 showed the presents of snapper (*Pagrus auratus*) and blue cod (*Parapercis colias*) within the Auckland Offshore Sand Extraction Site. Pelagic species such as Kahawai (*Arripis trutta*), kingfish (*Seriola ialandii*), Trevally (*Pseudocaranx dentex*) as well as other bottom feeding species such as John Dory (*Zeus faber*), Red gurnard (*Chelidonichthys kumu*) and Tarakihi (*Nemadactylus macropterus*) are either know, from fish reported catch or expected to be present all or at some of the time in the Auckland Offshore Sand Extraction Site at varying abundances. A number of species of sharks are also expected to be present in the deep water sand extraction area at times throughout the year.

Most fished coastal marine teleost finfish have life histories that can be divided up into spawning/reproduction, eggs and larval periods, a juvenile phase, and an adult phase, when reproductive maturity is reached. The level of knowledge varies greatly across species with snapper and blue cod most heavily studied. The sensitivity to the effects of sand extraction is likely to vary between life stages and fish species. It is also known that many fish species spend their juvenile life stage in more sheltered estuarine habitats meaning juvenile fish are not abundant in the sand extraction area.

Fin fish may be effected by a number of factors related to the operation of the sand dredge, these include;

- noise effects
- entrainment
- sub lethal effects from suspended sediment
- food source reduction.

Underwater noise levels from the dredge are unknown but not expected to be significant, given the pump is above water sucking water and sediment up through the pipe across the sieves above water and back into the surface water. It is not expected that fish will be entrained into the dredge as the water flow will be targeted at sucking sediment up from the sea bed. It is expected that the mobile fish species present will avoid the sand dredged during operation and thus avoid entrainment. Recent studies have identified that increased suspended solids in the water column is detrimental to juvenile snapper health in estuarine environments (Lowe, 2013). While the research was aimed at the effects of increased terrestrial sediment inputs, the discharge of fine marine sediments could have similar effects. The percentage of fine sediments in the seabed of the sand extraction area is and has been low ranging from 0 – 3 percent meaning the amount of fine discharged from the sand dredge will be small and unlikely to adversely affect fish present. Benthic biota forms the basis of many fish diets a reduction as a result sand dredging could potentially impact bottom feeding fish species. The benthic biota collected in Area 1 over time does not suggest a decrease in abundance of biota, and comparison between the control area and Area 1 in 2017 suggest that dredging if anything increases the abundance of biota. Species present in the benthic biota may have changed over time but it is not clear if this is a result of sand extraction.

While the fish species present or likely to be present are ecologically and economically important the effects of the sand extraction are expected be no more than minor.

4.6 Mammals

Marine mammals, such as cetaceans (whales and dolphins) and pinnipeds (seals and sea lions) are either resident or use the northeast region of New Zealand as part of a migratory path and/or feeding and nursery grounds.

Ten cetacean species have been recorded in the Hauraki Gulf;

- Common dolphins (*Delphinus delphis*),
- Bottlenose dolphins (*Tursiops truncatus*),
- Arnoux's beaked whales (*Berardius arnouxii*),
- Blue whale (*Balaenoptera musculus intermedia*),
- Bryde's whale (*Balaenoptera edeni brydei*),
- Humpback whales (*Megaptera novaeangliae*),
- Killer whales (*Orcinus orca*),
- Long-finned pilot whales (*Globicephala melas*),
- Minke whale (*Balaenoptera acutorostrata*),
- Sei whale (*Balaenoptera borealis*).

Studies of dolphins in New Zealand have determined that the common dolphin, *Delphinus delphis* is commonly found north of the Subtropical Convergence (approximately 42°S) (Gaskin, 1968 and Neumann, *et al.*, 2002). A study of Bottlenose dolphins, *Tursiops truncatus* in the Hauraki Gulf (Dwyer, 2014, Dwyer, *et al.*, 2014, Dwyer, *et al.*, 2016,) showed a hot spot on the western side of Great Barrier Island with Bottlenose dolphins recorded on 19 of 20 survey months (Dwyer, 2014, Dwyer *et al.*, 2014, Dwyer *et al.*, 2016). The study showed dolphins were more likely encountered in deeper waters in summer and shallower water in winter. Both dolphin species are resident in the Hauraki Gulf year round.

Visser (2000) determined that out of a population of approximately 115 orcas in New Zealand waters, the highest number of sightings were in the northeast coast region. The majority of the sightings were in nearshore areas (Visser, 2000). Therefore, it is highly likely that New Zealand orcas, *Orcinus orca* will be present for transient passage through the deep water sand extraction area at times throughout the year.

All three species have been observed at Goat Island marine reserve to the south of the sand extraction area.

At least two species of pinnipeds are present with in the Hauraki Gulf. The New Zealand fur seals (*Arctocephalus forsteri*) are present within the Hauraki Gulf and have been recorded at Goat Island Marine reserve and to the north at the Poor Knight Islands. The leopard seal (*Hydrurga leptonyx*) has also been recorded in the Waitamata harbour and at Tutukaka Harbour to the north. Therefore it is like both of these species have or may pass through the sand extraction area.

Marine mammals are not resident within the Auckland Offshore Sand Extraction Site, however they are likely to be transient, either moving from one area to another as part of a seasonal migration or foraging. The intermittent operation of the sand dredge is unlikely to have adverse effects on any cetaceans or pinnipeds present within the dredging area. The expected noise levels produced by the dredge are at worst only like to result in avoidance of the area while the dredge is in operation.

4.7 General Implications of Findings

The combined weight of evidence approach of multiple survey techniques (grab samples, dredge tows and video survey) while not sufficient to detect small changes in benthic community structure, has provided sufficient data to assess the broad scale effects of sand extraction.

The abundance and diversity of benthic fauna identified in this study is typical of the Pakiri-Mangawhai subtidal environment. This is characterised by a high abundance of crustaceans, predominantly amphipods and hermit crabs, a high diversity of polychaete worms (>20 species) and patchy aggregations of larger bivalve species e.g., scallops *Pecten novaezelandiae*. The Hawaiki undersea cable study Bioresearches (2016) showed changes in species composition across the shore with increasing depth. However, characteristically for soft-sediment assemblages, the distribution of species was highly variable across all taxonomic classes.

Using a combination of grab samples, video/still photography and dredge tows enables a comprehensive survey of the sea bed by ensuring that dominant forms of all taxonomic classes are encountered. The species communities identified during the present survey were not greatly dissimilar to those reported in the 2003, 2006 and 2011 surveys. However, in the 2003 study scallops were not observed in either grab samples or video surveys within or outside sand extraction Area 1. However, note that dredge tows were not conducted in 2003. Dredge tows were the most efficient method of sampling in large bivalves in later studies. Conversely, aggregations of horse mussels (*Atrina zelandica*), were not observed by video or still photography or in dredge tows in the 2006, 2011 and 2017 studies, but were observed in shallow water in the 2003 survey (ASR, 2003). However, a number of juvenile horse mussels were recorded in the grab samples from Area 1 in 2017. The occurrence of scallops in recent studies is possibly the result of the sand extraction area being restricted from commercial scallop fishing in the years prior to 2006 (ASR, 2006). The lack of scallops in 2003 may have been false, in that the use of dredge tows may have recorded their presence albeit at low numbers. Whereas the reduction in numbers of horse mussels has a number of potential causes including storm damage, sediment disturbance from sand extraction, changes in water turbidity characteristics, or changes in sediment grain size as their distribution tends to be restricted to near-shore fine sediment types (ASR, 2003).

Based on previous work in the area, a general trend of increasing abundance with increasing depth and mud content has been described over the entire area of the consent (Riddle, 2000). This extends some 18 km offshore and to depths greater than 50 m. However, previous studies have been unable to identify any firm relationships between dominant community classes and sediment characteristics of the environment (Cole, 1998; Riddle, 2000; ASR, 2003). Similar results were obtained by Taylor and Morison in Omaha Bay, with higher diversity and abundance in deeper muddier habitats (Taylor and Morison, 2008). A study by Bioresearches (2016) at Mangawhai to the north of the sand extraction area showed a relatively feature less gradation of sea bed types from;

- Small rippled fine clean sand (low water spring – 0.5 km, depth 0 – 10 m)
- Flat fine sand with shell (0.6 – 1.8 km, depth 12 – 27m)
- Long wave rippled fine sand with shell (2.0 – 2.7 km, depth 30 – 35m)
- Flat fine sand with shell (3.0 – 5.5 km, depth 37 – 48 m)
- Humpy fine sand with shell (6.0 – 7.5 km, depth 46 – 48m)
- Flat muddy sand with shell (7.5 – 14 km, depth 48 – 60m)

In general the biota is relatively sparse but over laying the sea bed types is a distribution of ecological habitat types, dominated by the following biota;

- Sand dollar, paddle crab (low water spring – 0.3 km, depth 0 – 7 m)
- Sparse hermit crabs, heart urchins, starfish (0.4 – 0.9 km, depth 8 – 18m)
- Sparse Scallop bed (1.0 – 3.5 km, depth 18 – 40 m)
- Sparse Xenophora and sponge garden (4.0 – 6.5 km, depth ~ 45m)
- Worm eel garden (7.0 – 14.0 km, depth 47 – 60 m)

The inshore sand extraction under resource consent Permits 28174 and 28173 is located in water less than 10m the ecology of this inshore area is different to that of the Auckland Offshore Sand Extraction Site. Inshore biota are suited to the high energy wave mobile sediment environment in the shallow water, while the Auckland Offshore Sand Extraction Site biota are more suited to the more stable less mobile environment provided by the water deeper than 25 m. While some species may be common to both areas any effects on the ecology of the inshore area are unlikely to have any impact on the ecology of the Auckland Offshore Sand Extraction Site and vice versa.

The Auckland Offshore Sand Extraction Site is located in an area of coarse grain sand (25-35 m water depth), a result of the long-term response to physical forces. The sediment characteristics at this depth (a band between 20 and 45 m deep, centred on 35 m) are the result of the maximum wave height climate (Black and Oldman, 1999). Previous reviews of international literature indicate that the most important factors relating to the magnitude of the biological impacts and recovery times due to dredging are,

- the intensity of the disturbance (dredging);
- the sediment type being disturbed, and;
- the amount of exposure to natural disturbance (and thus sediment mobility) experienced at the dredge/trawl site (a review of this literature is presented in ASR, 2001).

As a rule, the coarser the grain size and the higher the amount of natural exposure, the lower the likelihood of permanent changes to the seabed community due to dredging activities. Reduced impacts of this nature are predominantly due to the biota being already adapted to the harsh natural environment. Off the Pakiri coast the sediment type is coarse sand, and this material is mobile during large storms / wave conditions as is evidenced by bed forms in the sand extraction and control areas (Healy *et al.*, 1996; Riddle, 2000; ASR, 2003; ASR, 2006; Bioresearches, 2011; and section 4.1). The continuation of these features suggest that the sand extraction activity to date has had very little, if any, impact on the physical characteristics of the seabed. It has been shown that changes in grain size composition observed in Area 1 over time are not statistically significantly different to those changes observed in the Control area over time, therefore there has not been a measureable effect of sand extraction on the grain size composition.

Despite the lack of a complete set of before, after and control benthic biota data it has still been possible to determine that biota is not vastly different to that recorded prior to sand extraction. With the majority of the biota (crustacea) highly mobile and well adapted to abrasive, mobile sand substrates changes in biota were not expected as a result of the sand extraction process. However, some of the larger and less mobile biota have shown some changes. The horse mussel was present in beds in 2003 prior to sand extraction but has since declined to a few patchy juvenile individuals is potentially one example of a sand extraction disturbance effect. The opposite was recorded for scallops which were not recorded prior to sand extraction but have since increased in numbers and are wide spread throughout the area but are patchily distributed.

The current benthic biota communities in the sand extraction areas and the control area show remarkably similar proportions of the diversity of major taxa groupings (Figure 4.8), indicating little effect of sand extraction on the general species composition. However, Figure 4.8 shows that there are more crustaceans and fewer polychaete worms in the sand extraction area than the control area, suggesting crustaceans are better able to survive the periodic disturbance of sand extraction than polychaete worms. Numbers of other species are largely unaffected.

Provided that the deep water sand extraction dredge operation or other factors do not result in physical change of depth or grain size, then it is expected that continued operation of the dredge at its current rate of sand extraction is not likely to cause ecological effects, beyond those observed to date.

5. SUMMARY OF EFFECTS TO DATE OF OFFSHORE DREDGING ON ECOLOGY

Beca (2019) summarises the sands extraction over the period of the consent. Sand has been extracted from Area 1 since 2003, while limited sand has been extracted from Area 2 since 2011. The quantities recovered up to 2019 under the offshore consent are approximately 1,450,000 m^3 from Area 1 and 75,000 m^3 from Area 2.

The comments presented are based on comparisons of data obtained as part of monitoring of the offshore dredging consent and as far as can be deduced from background information available. These effects include:

- changes to benthic biota
- changes in fish, marine mammals and birds

These components are discussed as follow:

5.1 Benthic Biota and Macrobenthic Epifauna

Sample collection has been completed by a number of parties over time resulting in variation in sample type and sieve size used. This has resulted in data that differs across time that can only be compared non-parametrically thorough comparisons of species percentages. In addition the ability to identify biota to species level has changed over time, thus higher taxonomic grouping is required to make the data comparable. Additionally the lack of replicated data on benthic biota from the initial surveys of the sand extraction areas (Area 1 and Area 2) has limited the analysis of effects of sand extraction.

From the Control site data that is available it can be seen that there was a natural variation over time over above any effects of sand extraction. Comparison between the 2011 and 2017 control site samples (Figure 4.6) showed the percentage abundance of crustacea and gastropods has increased between 2011 and 2017, while the percentage abundance of bivalves has decreased. At the same time the percentage diversity of gastropods has increased while the percentage diversity of polychaetes, crustacea and bivalves has decreased. Similar comparative data was not available for the sand extraction Area 1 for the same time period.

In 2017 the comparison of percentage abundance and composition between the control site and Area 1 (Figure 4.8) showed that sand extraction had little or no effect on the percent composition of the major taxa groupings. The effect of sand extraction in Area 1 resulted in relatively fewer polychaetes and bivalves but increased numbers of crustacea, this is in alignment with the expected effects of sand extraction. As the sand is extracted bivalves are expected to suffer some shell damage and potential mortality as a result of passage through the dredge prior to return to the sea bed via the oversize waste pipe, thus the numbers are expected to be reduced. It is unknown if species are differentially effected by the passage through the dredge, however it could be expected that more fragile species will be more greatly affected than more robust species. The softer bodied polychaetes will also suffer mortality by passage through the dredge but will additionally suffer predation on their decent to the sea bed by birds and fish. This mortality is reflected by the decrease in abundance in Area 1 relative to the Control area.

Gastropods are generally more robust and compact than bivalves and by observation suffer less damage by the passage through the dredge, hence their abundance has not been as greatly affected by the sand extraction activity. The generally small crustacea are for the most part short lived and are either predatory or opportunistic feeders. The passage of the smaller crustacea such as amphipods through the sand dredge is not expected to result in significant mortality, given their smaller size and robustness. The disturbance cause by the sand dredge is likely to have created advantageous conditions, through deposition of food in the form of damaged animals like bivalves, echinoderms, polychaetes etc, for such species to thrive on and hence the relative abundance of crustacea has increased in Area 1 relative to the Control area.

5.2 Fish, Marine Mammals and Birds

No direct assessment has been made of the populations of either fish, mammals or birds prior to and following sand dredging, or in comparison between areas dredged and not dredged. However no direct adverse effects to marine mammals or birds have been reported by the barge operators. The operation of the sand extraction dredge results in the discharge of oversized material and fine material passing over the sand screen. The discharge of this material creates a plume behind the sand barge, which has increased turbidity and contains whole or fragments of benthic biota (Figure 5.1). It has been observed that birds (Red billed gulls, *Chroicocephalus novaehollandiae scopulinus*) frequent the area of the plume close to the barge foraging for biota fragments (Figure 5.1).

Figure 5.1 Sand barge in operation showing discharge of material, turbid plume and birds foraging.

Fish may be effected by a number of factors related to the operation of the sand dredge, these include;

- noise effects
- entrainment
- sub lethal effects from suspended sediment
- food source reduction.

Underwater noise levels from the dredge are unknown but not expected to be significant. It is not expected that fish will be entrained into the dredge as the water flow will be targeted at sucking sediment up from the sea bed. The sand dredge moves over the sea bed at speed of 1 – 2 knots, thus it is expected that the mobile fish species present will be able to avoid the sand dredged during operation and thus avoid entrainment. Fish species that live within the sediment such as Opalfish, (*Hemerocoetes monopterygius*) or short finned worm eels (*Scolecenchelys australis*) which have been recorded further north and off shore from the sand extraction area may be entrained.

Recent studies have identified that increased suspended solids in the water column is detrimental to juvenile snapper health in estuarine environments (Lowe, 2013). While the research was aimed at the effects of increased terrestrial sediment inputs, the discharge of fine marine sediments from the sand barge could have similar effects. However the percentage of fine sediments in the seabed of the sand extraction area is and has been low ranging from 0 – 3 percent meaning the amount of fine discharged from the sand dredge that remains suspended will be small and unlikely to adversely affect fish present. Additionally the sand barge is currently only operational in the area for periods of approximately 5 hours, after which time the current barge under normal operation reaches its load capacity and must return to port for unloading.

Benthic biota forms the basis of many fish diets a reduction as a result sand dredging could potentially impact bottom feeding fish species. The benthic biota collected in deep water sand Area 1 over time does not suggest a change in species composition in biota, and comparison between the control area and Area 1 in 2017 suggest that dredging if anything increases the abundance of some species of biota.

While the fish species present or likely to be present are ecologically and economically important the effects of the sand extraction are expected be no more than minor.

Three species Common dolphins (*Delphinus delphis*), Bottlenose dolphins (*Tursiops truncatus*) and Killer whales (*Orcinus orca*) have commonly been observed at Goat Island marine reserve to the south of the sand extraction area. In addition the New Zealand fur seals (*Arctocephalus forsteri*) are also present within the Hauraki Gulf and have been recorded at Goat Island Marine reserve. Other species may also be present refer section 4.6.

Marine mammals are not resident within the Auckland Offshore Sand Extraction Site, however they are likely to be transient, either moving from one area to another as part of a seasonal migration or foraging. The intermittent operation of the sand dredge is unlikely to have adverse effects on any cetaceans or pinnipeds present within the dredging area. The expected noise levels produced by the dredge are at worst only like to result in avoidance of the area while the dredge is in operation.

5.3 Effects of the Continuation of Sand Extraction

The effects of sand extraction are summarised in Figure 5.2. Benthic biota will be destroyed from the path of the dredge head, (Figure 5.3) through either removal, smothering or destruction caused by passage through the dredge head, pump, pipe and discharge. The significance of the impact depends on the value or uniqueness of the local community, the susceptibility of the community, the composition of the surficial seabed sediments, the dimensions of the area and the recovery rate of the benthic community.

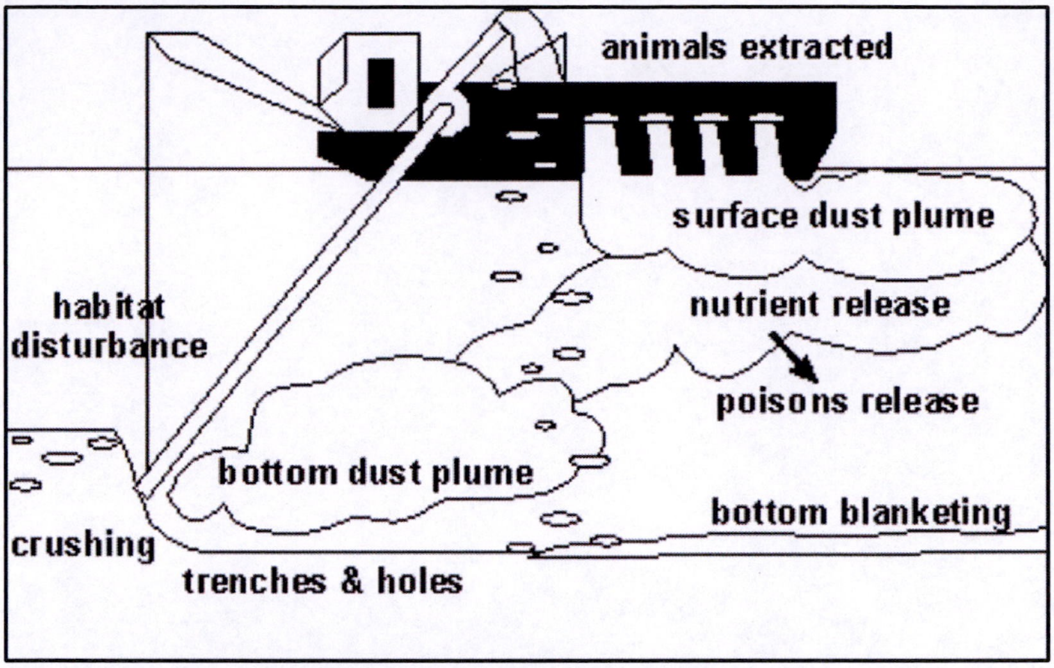

Figure 5.2 Summary of the effects of sand dredging.

Figure 5.3 Path of dredge head through sea bed. 2018, *curtesy of McCullum Brothers*

The benthic and near benthic communities of the proposed Auckland Offshore Sand Extraction Site (Figure 1.2) have been described and are not unique, in that they are a common along much of the north eastern coast of the north island. While they have value in that they provide the basis for significant fisheries, the effects to date do not indicate that the benthic communities will be degraded to the extent that these fisheries will be greatly affected. The loss of the local benthic fauna can have effects further down food chains. However, links and effects at higher trophic levels are not well known. The extraction activity may also inadvertently create an abundance of food in the form of damaged animals like bivalves or crustaceans. This can temporarily enhance numbers of fish and marine mammals present in the area.

As part of the 2017 monitoring Stony corals were recorded from one location within the sand extraction area, prior to this Stony corals had not been recorded in the sand extraction area. Stony corals are protected under the 2010 amendment of the Wildlife Act (1953), and as such should not intentionally be removed from the sea bed. However given their size of approximately 5 mm diameter they should pass through the dredge and be discharged back to the seabed. Since it is possible they could be damage by passage through the dredge it is recommended if they are know from an area, that this area be excluded from sand extraction until it has been shown they are no longer present.

The sea bed sediment is mostly course sand with very little fine mud (< 3 %) as shown by the particle size analysis (Table 2). Despite the differences in measurement methodologies, there is no evidence of ecologically significant changes in the particle size composition as a result of sand extraction activity, by comparison with control sites, or cumulatively over time. There are no sources of chemical contamination in or near the sand extraction area. Thus the composition of the seabed sediments will not result in adverse effects if disturbed.

Estimates of the time taken for a benthic community to recover from a disturbance event of the scale of sand dredging is between 6 months to several years. This is based on smaller biota with general short life spans re-establishing first from adjacent habitats and those larger species following but taking longer to grow to adult sizes. Seasonal timing will also have an effect on the speed of recovery, initially recovery will be by migration from adjacent habitats, and then by reproductive settlement which will be seasonal. The area proposed for sand extraction is 44 km^2, based on the currently available sand barge's operational parameters, 0.7 m wide dredge, to 0.3 m depth, 0.5 m/s speed, barge load 460 m^3, and some assumptions of sand retention, it is expected that an area of approximately 0.006 km^2 would be dredged per day. Based on this rate of dredging per day and assuming the same area is not dredged again it would take more than 22 years to dredge the complete area, given no limits on volume extracted. However the current consent limits the extraction to 150,000 m^3 per year which would result in it taking more than 25 years to dredge the entire area proposed once. Based on this frequency of dredging it is expected that the benthic communities will have more than recovered between dredging events assuming the dredging is spread out of the entire sand extraction area. Even if the dredging is concentrated to a smaller area such as the 9.6 km^2 of Area 1 dredging the return frequency given the limits is over 5 years, again long enough for benthic community recovery to have occurred.

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7. APPENDICES

Appendix 1 Sampling Area Positions

Table 5 Area 1 2003 grab sampling points (WGS 84 datum)

Site	World Geodetic System 1984		Off to on shore area				Long shore
	Latitude	Longitude	Off	>30	<30	In	Area
ASR01	-36.16521	174.68559		x			
ASR02	-36.16478	174.69061	x				
ASR03	-36.16785	174.68819		x			N
ASR04	-36.16922	174.68545		x			N
ASR05	-36.17171	174.68083				x	N
ASR06	-36.17107	174.68676		x			N
ASR07	-36.17340	174.68857		x			N
ASR08	-36.17198	174.69164		x			N
ASR09	-36.17024	174.69191		x			N
ASR10	-36.17331	174.69980	x				N
ASR11	-36.17494	174.69387		x			N
ASR12	-36.17620	174.69027			x		N
ASR13	-36.18060	174.68284				x	N
ASR14	-36.17913	174.69202			x		N
ASR15	-36.17749	174.69543		x			N
ASR16	-36.17891	174.69843		x			N
ASR17	-36.18087	174.69750		x			N
ASR18	-36.18103	174.69372			x		N
ASR19	-36.18409	174.69392			x		N
ASR20	-36.18357	174.69855		x			N
ASR21	-36.18161	174.70149		x			N
ASR22	-36.18210	174.70821	x				N
ASR23	-36.18410	174.70605		x			N
ASR24	-36.18627	174.70207		x			N
ASR25	-36.18992	174.69997			x		N
ASR26	-36.19335	174.69685				x	N
ASR27	-36.19224	174.70311			x		N
ASR28	-36.19013	174.70852		x			N
ASR29	-36.19373	174.70859			x		N
ASR30	-36.19531	174.70350			x		N
ASR31	-36.19675	174.71034			x		N
ASR32	-36.19702	174.71498		x			N
ASR33	-36.19267	174.71556		x			N

Site	World Geodetic System 1984		Off to on shore area				Long shore
	Latitude	Longitude	Off	>30	<30	In	Area
ASR34	-36.19485	174.71797		x			N
ASR35	-36.19432	174.72084	x				N
ASR36	-36.20125	174.71576			x		N
ASR37	-36.20146	174.71100			x		S
ASR38	-36.20558	174.70949				x	S
ASR39	-36.20511	174.71523			x		S
ASR40	-36.20722	174.71555			x		S
ASR41	-36.20156	174.72104		x			S
ASR42	-36.20236	174.72430		x			S
ASR43	-36.20289	174.73017	x				S
ASR44	-36.20543	174.72613		x			S
ASR45	-36.20632	174.72241		x			S
ASR46	-36.20987	174.72038			x		S
ASR47	-36.21659	174.72149				x	S
ASR48	-36.21299	174.72339			x		S
ASR49	-36.21130	174.72646			x		S
ASR50	-36.20902	174.73227		x			S
ASR51	-36.21241	174.73102		x			S
ASR52	-36.21394	174.73134			x		S
ASR53	-36.21674	174.72704			x		S
ASR54	-36.21986	174.73206			x		S
ASR55	-36.21855	174.73487			x		S
ASR56	-36.21256	174.73618		x			S
ASR57	-36.21411	174.74172	x				S
ASR58	-36.21696	174.73949		x			S
ASR59	-36.22119	174.73460			x		S
ASR60	-36.22484	174.73042				x	S
ASR61	-36.22331	174.73903			x		S
ASR62	-36.22135	174.74054		x			S
ASR63	-36.22294	174.74446		x			S
ASR64	-36.22473	174.74720		x			C
ASR65	-36.22770	174.74198			x		C

Table 6 Area 1 2003 video / drop camera sampling points (WGS 84 datum)

Location	World Geodetic System 1984			
	Beginning, Off shore		End, In shore	
	Latitude	Longitude	Latitude	Longitude
Video 1	-36.17165	174.68219	-36.16637	174.69355
Drop camera Transect 1				
102	-36.16720	174.69190		
101	-36.16810	174.68990		
100	-36.16850	174.68860		
99	-36.16910	174.68760		
98	-36.16940	174.68660		
97	-36.17000	174.68540		
96			-36.17050	174.68410
Video 2	-36.19652	174.70095	-36.18838	174.71440
Drop camera Transect 2				
66	-36.19830	174.72730		
67	-36.19930	174.72560		
68	-36.20050	174.72350		
69	-36.20230	174.72020		
70	-36.20250	174.71990		
71	-36.20370	174.71740		
72	-36.20560	174.71560		
73			-36.20560	174.71590

Location	World Geodetic System 1984			
	Beginning, Off shore		End, In shore	
	Latitude	Longitude	Latitude	Longitude
Drop camera Transect 3				
83	-36.21010	174.73580		
82	-36.21060	174.73510		
81	-36.21120	174.73440		
80	-36.21210	174.73320		
79	-36.21310	174.73200		
78	-36.21360	174.73110		
77	-36.21410	174.73000		
76	-36.21510	174.72870		
75	-36.21700	174.72590		
74			-36.21740	174.72530
Drop camera Transect 4				
95	-36.21980	174.74650		
94	-36.22030	174.74520		
93	-36.22090	174.74410		
92	-36.22150	174.74340		
91	-36.22210	174.74270		
90	-36.22270	174.74170		
89	-36.22320	174.74080		
88	-36.22390	174.74020		
87	-36.22450	174.73920		
86	-36.22520	174.73820		
85	-36.22590	174.73720		
84			-36.22660	174.73620

Table 7 Area 2 2006 grab sampling points (WGS 84 datum)

Site	World Geodetic System 1984	
	Latitude	Longitude
A2S01	-36.17071	174.69543
A2S02	-36.17174	174.69357
A2S03	-36.17377	174.68970
A2S04	-36.17077	174.68928
A2S05	-36.17049	174.69136
A2S06	-36.16978	174.69219
A2S07	-36.16730	174.69477
A2S08	-36.16675	174.69220
A2S09	-36.16495	174.68573
A2S10	-36.16143	174.68539
A2S11	-36.15999	174.68762
A2S12	-36.15855	174.68985
A2S13	-36.15860	174.68184
A2S14	-36.15829	174.67107
A2S15	-36.15443	174.68037
A2S16	-36.14924	174.68516
A2S17	-36.15004	174.67699
A2S18	-36.15032	174.67285
A2S19	-36.14682	174.66166
A2S20	-36.14287	174.67047
A2S21	-36.14103	174.67972
A2S22	-36.12848	174.67156
A2S23	-36.13011	174.66774
A2S24	-36.13173	174.66392
A2S25	-36.13241	174.65978
A2S26	-36.13720	174.65412
A2S27	-36.13113	174.65258
A2S28	-36.12822	174.65775
A2S29	-36.12684	174.66184
A2S30	-36.12258	174.66847
A2S31	-36.11842	174.66600
A2S32	-36.12268	174.65675
A2S33	-36.12308	174.65553
A2S34	-36.12883	174.64812
A2S35	-36.12302	174.64461
A2S36	-36.11745	174.65157
A2S37	-36.11230	174.66047
A2S38	-36.10780	174.65787
A2S39	-36.11188	174.65037
A2S40	-36.11491	174.64599
A2S41	-36.11793	174.64159
A2S42	-36.10887	174.64480
A2S43	-36.10718	174.64664
A2S44	-36.09887	174.65169
A2S45	-36.09991	174.64688
A2S46	-36.10096	174.64206
A2S47	-36.10329	174.63883
A2S48	-36.10585	174.63560
A2S49	-36.10027	174.63189
A2S50	-36.09422	174.63945
A2S51	-36.07849	174.63137
A2S52	-36.08195	174.62463
A2S53	-36.08567	174.62742
A2S54	-36.09237	174.62613
A2S55	-36.08761	174.62264
A2S56	-36.09667	174.63038
A2S57	-36.08861	174.63551
A2S58	-36.08395	174.63879
A2S59	-36.08949	174.64281
A2S60	-36.11092	174.64605
A2S61	-36.11140	174.63884
A2S62	-36.11584	174.64964
A2S63	-36.12029	174.66044
A2S64	-36.12016	174.66118
A2S65	-36.12941	174.66949
A2S66	-36.13651	174.66035
A2S67	-36.13824	174.66135
A2S68	-36.13968	174.66257
A2S69	-36.13412	174.66996
A2S70	-36.13550	174.68037
A2S71	-36.14471	174.67508
A2S72	-36.14646	174.67421
A2S73	-36.15415	174.66737
A2S74	-36.15166	174.68017
A2S75	-36.15364	174.68743
A2S76	-36.15661	174.68531
A2S77	-36.15844	174.68359
A2S78	-36.16642	174.67664
A2S79	-36.16321	174.68832
A2S80	-36.16120	174.69432
A2S81	-36.16818	174.69622
A2S82	-36.17529	174.68412
A2S83	-36.17075	174.68339
A2S84	-36.11521	174.65539
A2S85	-36.11654	174.65414
A2S86	-36.12041	174.64917
A2S87	-36.12073	174.64733
A2S88	-36.16659	174.69564
A2S89	-36.16920	174.69219
A2S90	-36.17148	174.69691
A2S91	-36.17385	174.69255

Table 8 Area 2 2006 video / drop camera sampling points (WGS 84 datum)

Location	World Geodetic System 1984			
	Beginning, Off shore		End, In shore	
	Latitude	Longitude	Latitude	Longitude
Drop camera Transect 1				
2	-36.08599	174.63354		
3	-36.08646	174.63266		
4	-36.08773	174.63101		
5	-36.08833	174.62972		
6	-36.08879	174.62853		
7	-36.08942	174.62752		
8			-36.09037	174.62606
Drop camera Transect 2				
16	-36.09834	174.64466		
15	-36.09893	174.64391		
14	-36.09933	174.64322		
13	-36.09965	174.64177		
12	-36.10034	174.63994		
11	-36.10113	174.63859		
10	-36.10226	174.63682		
9			-36.10384	174.63518
Drop camera Transect 3				
17	-36.11108	174.65307		
18	-36.11330	174.64862		
19	-36.11331	174.64852		
20	-36.11379	174.64662		
21	-36.11441	174.64500		
22	-36.11522	174.64276		
23			-36.11563	174.64210
Drop camera Transect 4				
31	-36.12343	174.66253		
30	-36.12431	174.66168		
29	-36.12518	174.66076		
28	-36.12384	174.65963		
27	-36.12515	174.65749		
26	-36.12607	174.65518		
25	-36.12714	174.65311		
24			-36.12815	174.65089
Drop camera Transect 5				
33	-36.13526	174.66999		
34	-36.13612	174.66833		
35	-36.13692	174.66642		
36	-36.13795	174.66520		
37	-36.13844	174.66355		
38	-36.13981	174.66141		
39	-36.14035	174.65970		
40			-36.14086	174.65881
Drop camera Transect 6				
48	-36.14624	174.67795		
47	-36.14690	174.67677		
46	-36.14787	174.67503		
45	-36.14865	174.67355		
44	-36.14951	174.67228		
43	-36.15013	174.67085		
42	-36.15109	174.66894		
41			-36.15190	174.66737
Drop camera Transect 7				
49	-36.15911	174.68716		
50	-36.15985	174.68493		
51	-36.16134	174.68306		
52	-36.16204	174.68217		
53	-36.16274	174.68095		
54	-36.16372	174.67961		
55	-36.16479	174.67822		
56			-36.16582	174.67670
Drop camera Transect 8				
64	-36.16906	174.69461		
63	-36.16975	174.69362		
62	-36.17067	174.69201		
61	-36.17173	174.69016		
60	-36.17247	174.68914		
59	-36.17327	174.68757		
58	-36.17391	174.68655		
57			-36.17492	174.68464

Table 9 Area 2 2006 dredge tow sampling points (WGS 84 datum)

Site No. (start)	World Geodetic System 1984 Latitude	Longitude	Site No. (end)	World Geodetic System 1984 Latitude	Longitude
1	-36.16284	174.68736	1	-36.16287	174.68730
2	-36.16758	174.68444	2	-36.16846	174.68442
3	-36.15701	174.67664	3	-36.15751	174.67623
4	-36.14182	174.67190	4	-36.14182	174.67190
5	-36.14574	174.66755	5	-36.14807	174.66788
6	-36.12673	174.66052	6	-36.12796	174.65872
7	-36.12978	174.65640	7	-36.13099	174.65447
8	-36.12358	174.65200	8	-36.12154	174.65337
9	-36.11655	174.65392	9	-36.11388	174.65360
10	-36.10625	174.64792	10	-36.10467	174.64843
11	-36.09408	174.63915	11	-36.09287	174.63763
12	-36.09093	174.63050	12	-36.08997	174.62905

Table 10 Area 1, Area 2 and Control Area 2011 grab sampling points (WGS 84 datum)

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
A1S03	-36.16785	174.68819		x			N
A1S04	-36.16922	174.68546		x			N
A1S05	-36.17171	174.68083				x	N
A1S06	-36.17107	174.68677		x			N
A1S07	-36.17340	174.68857		x			N
A1S08	-36.17198	174.69164		x			N
A1S10	-36.17331	174.69980	x				N
A1S11	-36.17495	174.69388		x			N
A1S12	-36.17620	174.69028			x		N
A1S13	-36.18060	174.68285				x	N
A1S14	-36.17913	174.69202			x		N
A1S15	-36.17749	174.69543		x			N
A1S16	-36.17891	174.69843		x			N
A1S17	-36.18087	174.69751		x			N
A1S18	-36.18103	174.69373			x		N
A1S19	-36.18409	174.69392			x		N
A1S20	-36.18357	174.69855		x			N
A1S21	-36.18161	174.70149		x			N
A1S22	-36.18210	174.70821	x				N
A1S23	-36.18410	174.70605		x			N
A1S24	-36.18627	174.70207		x			N
A1S25	-36.18992	174.69998			x		N
A1S26	-36.19335	174.69685				x	N
A1S27	-36.19225	174.70311			x		N
A1S28	-36.19013	174.70853		x			N
A1S29	-36.19373	174.70859			x		N
A1S30	-36.19531	174.70349			x		N
A1S31	-36.19675	174.71034			x		N
A1S32	-36.19702	174.71498		x			N
A1S33	-36.19267	174.71556		x			N
A1S34	-36.19485	174.71797		x			N
A1S35	-36.19432	174.72084	x				N
A1S36	-36.20124	174.71576			x		N
A1S37	-36.20146	174.71100			x		S
A1S38	-36.20558	174.70949				x	S
A1S39	-36.20511	174.71523			x		S
A1S40	-36.20722	174.71555			x		S
A1S41	-36.20156	174.72104		x			S
A1S42	-36.20236	174.72429		x			S
A1S43	-36.20289	174.73016	x				S
A1S44	-36.20543	174.72614		x			S
A1S45	-36.20632	174.72241		x			S
A1S46	-36.20987	174.72038			x		S
A1S47	-36.21659	174.72148				x	S
A1S48	-36.21299	174.72339			x		S
A1S49	-36.21130	174.72646			x		S
A1S50	-36.20902	174.73227		x			S
A1S52	-36.21394	174.73134			x		S
A1S53	-36.21674	174.72704			x		S
A1S54	-36.21986	174.73206			x		S
A1S55	-36.21855	174.73486			x		S
A1S56	-36.21256	174.73618		x			S
A1S57	-36.21410	174.74171	x				S
A1S58	-36.21696	174.73949		x			S
A1S59	-36.22119	174.73460			x		S
A1S60	-36.22484	174.73042				x	S
A1S61	-36.22331	174.73903			x		S

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
A1S62	-36.22135	174.74054		x			S
A1S63	-36.22294	174.74446		x			S
A2S01	-36.17072	174.69542		x			N
A2S04	-36.17078	174.68929		x			N
A2S05	-36.17050	174.69136		x			N
A2S07	-36.16731	174.69476	x				N
A2S08	-36.16676	174.69220	x				N
A2S09	-36.16496	174.68573		x			A2
A2S10	-36.16144	174.68538					A2
A2S11	-36.16000	174.68762					A2
A2S12	-36.15855	174.68985					A2
A2S13	-36.15860	174.68184					A2
A2S14	-36.15829	174.67107					A2
A2S15	-36.15443	174.68037					A2
A2S16	-36.14925	174.68515					A2
A2S17	-36.15004	174.67699					A2
A2S18	-36.15033	174.67285					A2
A2S19	-36.14683	174.66167					A2
A2S20	-36.14288	174.67047					A2
A2S21	-36.14103	174.67972					A2
A2S22	-36.12849	174.67157					A2
A2S23	-36.13012	174.66774					A2
A2S24	-36.13174	174.66393					A2
A2S25	-36.13242	174.65977					A2
A2S26	-36.13720	174.65411					A2
A2S27	-36.13113	174.65259					A2
A2S28	-36.12822	174.65775					A2
A2S29	-36.12685	174.66183					A2
A2S30	-36.12258	174.66847					A2
A2S31	-36.11843	174.66600					A2
A2S33	-36.12309	174.65552					A2
A2S34	-36.12883	174.64812					A2
A2S35	-36.12303	174.64461					A2
A2S36	-36.11746	174.65157					A2
A2S37	-36.11231	174.66046					A2
A2S38	-36.10781	174.65787					A2
A2S39	-36.11189	174.65038					A2
A2S40	-36.11491	174.64598					A2
A2S41	-36.11794	174.64159					A2
A2S42	-36.10888	174.64481					A2
A2S43	-36.10719	174.64664					A2
A2S44	-36.09887	174.65169					A2
A2S45	-36.09992	174.64688					A2
A2S46	-36.10097	174.64206					A2
A2S47	-36.10330	174.63882					A2
A2S48	-36.10586	174.63560					A2
A2S49	-36.10027	174.63188					A2
A2S50	-36.09422	174.63945					A2
A2S51	-36.07850	174.63136					A2
A2S52	-36.08195	174.62463					A2
A2S53	-36.08568	174.62741					A2
A2S54	-36.09238	174.62613					A2
A2S55	-36.08762	174.62263					A2
A2S56	-36.09667	174.63039					A2
A2S57	-36.08862	174.63551					A2
A2S58	-36.08396	174.63879					A2
A2S59	-36.08949	174.64281					A2

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
A2S61	-36.11140	174.63884					A2
A2S63	-36.12029	174.66043					A2
A2S65	-36.12942	174.66948					A2
A2S66	-36.13652	174.66034					A2
A2S68	-36.13968	174.66257					A2
A2S69	-36.13412	174.66995					A2
A2S70	-36.13551	174.68036					A2
A2S71	-36.14471	174.67508					A2
A2S72	-36.14647	174.67421					A2
A2S73	-36.15416	174.66737					A2
A2S74	-36.15166	174.68016					A2
A2S75	-36.15364	174.68742					A2
A2S76	-36.15662	174.68532					A2
A2S77	-36.15845	174.68359					A2
A2S78	-36.16643	174.67664					A2
A2S79	-36.16322	174.68832		x			A2
A2S80	-36.16121	174.69432	x				A2
A2S82	-36.17529	174.68413				x	N
A2S83	-36.17075	174.68340			x		N
A2S84	-36.11522	174.65540					A2
A2S85	-36.11654	174.65413					A2
A2S86	-36.12042	174.64917					A2
A2S87	-36.12074	174.64732					A2
A2S89	-36.16921	174.69218		x			N

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
CTS1s	-36.23011	174.74084			x		C
CTS1.01	-36.22955	174.74171			x		C
CTS1.02	-36.22900	174.74258			x		C
CTS1.03	-36.22843	174.74344			x		C
CTS1.04	-36.22789	174.74428			x		C
CTS1.05	-36.22732	174.74515			x		C
CTS1.06	-36.22675	174.74600			x		C
CTS1.07	-36.22619	174.74690		x			C
CTS1.08	-36.22562	174.74776		x			C
CTS1.09	-36.22507	174.74864		x			C
CTS1.10	-36.22452	174.74951		x			C
CTS1e	-36.22404	174.75024		x			C
CTS2s	-36.23653	174.74980			x		C
CTS2.01	-36.23583	174.75053			x		C
CTS2.02	-36.23513	174.75125			x		C
CTS2.03	-36.23447	174.75195			x		C
CTS2.04	-36.23379	174.75266			x		C
CTS2.05	-36.23309	174.75340			x		C
CTS2.06	-36.23240	174.75409		x			C
CTS2.07	-36.23171	174.75484		x			C
CTS2.08	-36.23099	174.75557		x			C
CTS2.09	-36.23031	174.75630		x			C
CTS2.10	-36.22961	174.75700		x			C
CTS2.11	-36.22896	174.75771		x			C
CTS2e	-36.22844	174.75826		x			C

Table 11 Control Area 2011 drop camera sampling points (WGS 84 datum)

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
CTS1s	-36.23011	174.74084			x		C
CTS1.01	-36.22955	174.74171			x		C
CTS1.02	-36.22900	174.74258			x		C
CTS1.03	-36.22843	174.74344			x		C
CTS1.04	-36.22789	174.74428			x		C
CTS1.05	-36.22732	174.74515			x		C
CTS1.06	-36.22675	174.74600			x		C
CTS1.07	-36.22619	174.74690		x			C
CTS1.08	-36.22562	174.74776		x			C
CTS1.09	-36.22507	174.74864		x			C
CTS1.10	-36.22452	174.74951		x			C
CTS1e	-36.22404	174.75024		x			C

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
CTS2s	-36.23653	174.74980			x		C
CTS2.01	-36.23583	174.75053			x		C
CTS2.02	-36.23513	174.75125			x		C
CTS2.03	-36.23447	174.75195			x		C
CTS2.04	-36.23379	174.75266			x		C
CTS2.05	-36.23309	174.75340			x		C
CTS2.06	-36.23240	174.75409		x			C
CTS2.07	-36.23171	174.75484		x			C
CTS2.08	-36.23099	174.75557		x			C
CTS2.09	-36.23031	174.75630		x			C
CTS2.10	-36.22961	174.75700		x			C
CTS2.11	-36.22896	174.75771		x			C
CTS2e	-36.22844	174.75826		x			C

Table 12 Control Area 2011 dredge tow sampling points (WGS 84 datum)

Site	World Geodetic System 1984				Distance (m)
	Beginning		End		
	Latitude	Longitude	Latitude	Longitude	
A	-36.23365	174.74940	-36.23137	174.74939	255
B	-36.23004	174.75035	-36.22794	174.75082	238
C	-36.22690	174.75169	-36.22479	174.75069	252

Table 13 Area 1 and Control Area 2017 drop camera and grab sampling points (WGS 84 datum)

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
TN W	-36.16616	174.67899			x		A2
TN M	-36.16419	174.68292		x			A2
TN E	-36.16209	174.68713		x			A2
T0 W	-36.17173	174.67974				x	N
T0 0	-36.17081	174.68148			x		N
T0 1	-36.16985	174.68343			x		N
T0 2	-36.16893	174.68533		x			N
T0 3	-36.16793	174.68721		x			N
T0 4	-36.16697	174.68915		x			N
T0 5	-36.16605	174.69118		x			N
T0 E	-36.16502	174.69306	x				N
T1 W	-36.17806	174.68847			x		N
T1 M	-36.17566	174.69310		x			N
T1 E	-36.17356	174.69723		x			N
T2 W	-36.18726	174.69167				x	N
T2 0	-36.18622	174.69355			x		N
T2 1	-36.18485	174.69592			x		N
T2 2	-36.18347	174.69831		x			N
T2 3	-36.18218	174.70070		x			N
T2 4	-36.18083	174.70308		x			N
T2 5	-36.17984	174.70492		x			N
T2 E	-36.17877	174.70675	x				N
T3 W	-36.19303	174.70075			x		N
T3 M	-36.18955	174.70592		x			N
T3 E	-36.18654	174.71044		x			N
T4 W	-36.20152	174.70570				x	N
T4 0	-36.20034	174.70734			x		N
T4 1	-36.19896	174.70930			x		N
T4 2	-36.19735	174.71134			x		N
T4 3	-36.19581	174.71348		x			N
T4 4	-36.19422	174.71566		x			N
T4 5	-36.19262	174.71770		x			N
T4 E	-36.19139	174.71932	x				N
T5 W	-36.20647	174.71538			x		S
T5 M	-36.20328	174.71940			x		S
T5 E	-36.19979	174.72378		x			S
T6 W	-36.21498	174.72048				x	S

Site	World Geodetic System 1984		Off to On shore area				Long shore Area
	Latitude	Longitude	Off	>30	<30	In	
T6 0	-36.21368	174.72202			x		S
T6 1	-36.21243	174.72369			x		S
T6 2	-36.21097	174.72558			x		S
T6 3	-36.20941	174.72746		x			S
T6 4	-36.20789	174.72950		x			S
T6 5	-36.20626	174.73129		x			S
T6 E	-36.20505	174.73294	x				S
T7 W	-36.21984	174.73038			x		S
T7 M	-36.21693	174.73406		x			S
T7 E	-36.21402	174.73773		x			S
T8 W	-36.22843	174.73534				x	S
T8 0	-36.22719	174.73702			x		S
T8 1	-36.22579	174.73880			x		S
T8 2	-36.22439	174.74053			x		S
T8 3	-36.22308	174.74238			x		S
T8 4	-36.22171	174.74411		x			S
T8 5	-36.22061	174.74558		x			S
T8 E	-36.21934	174.74719	x				S
T9 W	-36.23077	174.73842				x	C
T9 0	-36.22951	174.74002			x		C
T9 1	-36.22829	174.74168			x		C
T9 2	-36.22709	174.74337			x		C
T9 3	-36.22586	174.74497			x		C
T9 4	-36.22459	174.74659		x			C
T9 5	-36.22311	174.74860		x			C
T9 E	-36.22187	174.75024	x				C
TC W	-36.23182	174.74510			x		C
TC M	-36.22902	174.74862		x			C
TC E	-36.22616	174.75220		x			C
T10 W	-36.23670	174.74680				x	C
T10 0	-36.23542	174.74844		.	x		C
T10 1	-36.23385	174.75026			x		C
T10 2	-36.23227	174.75208			x		C
T10 3	-36.23073	174.75400		x			C
T10 4	-36.22918	174.75585		x			C
T10 5	-36.22793	174.75737		x			C
T10 E	-36.22664	174.75893	x				C

Table 14 Area 1 and Control Area 2017 dredge tow sampling points (WGS 84 datum)

Site	Date	Time	World Geodetic System 1984				Distance (m)
			Beginning		End		
			Latitude	Longitude	Latitude	Longitude	
T0 A	15 Dec 2017	16:00	-36.16969	174.68330	-36.17045	174.68385	97
T0 B	18 Dec 2017	11:50	-36.16833	174.68637	-36.16907	174.68689	94
T0 C	18 Dec 2017	11:40	-36.16698	174.68916	-36.16771	174.68979	99
T2 A	15 Dec 2017	16:20	-36.18450	174.69558	-36.18525	174.69621	100
T2 B	18 Dec 2017	11:20	-36.18241	174.69930	-36.18316	174.69994	101
T2 C	18 Dec 2017	11:10	-36.18048	174.70277	-36.18122	174.70341	100
T4 A	15 Dec 2017	16:30	-36.19859	174.70889	-36.19926	174.70963	125
T4 B	18 Dec 2017	10:38	-36.19621	174.71204	-36.19688	174.71279	100
T4 C	18 Dec 2017	10:55	-36.19387	174.71525	-36.19452	174.71601	100

Site	Date	Time	World Geodetic System 1984				Distance (m)
			Beginning		End		
			Latitude	Longitude	Latitude	Longitude	
T6 A	18 Dec 2017	10:30	-36.21213	174.72332	-36.21277	174.72409	100
T6 B	18 Dec 2017	10:20	-36.20984	174.72616	-36.21050	174.72693	100
T6 C	18 Dec 2017	10:05	-36.20753	174.72909	-36.20818	174.72985	100
T8 A	18 Dec 2017	9:25	-36.22548	174.73842	-36.22615	174.73917	100
T8 B	18 Dec 2017	9:35	-36.22335	174.74120	-36.22401	174.74195	99
T8 C	18 Dec 2017	9:45	-36.22139	174.74374	-36.22204	174.74450	99
TC A	18 Dec 2017	9:15	-36.23151	174.74470	-36.23215	174.74548	100
TC B	18 Dec 2017	8:45	-36.22871	174.74822	-36.22935	174.74900	100
TC C	18 Dec 2017	8:30	-36.22585	174.75181	-36.22649	174.75259	100

Appendix 2 Grain size results

Table 15 Summary Sediment Grain Size Data 2003 (Percentage by Weight)

Site	Size class (mm) Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay	Median Size	Graphic Mean Size	Sorting	Skewness	Characterization		
	>2.00	2.00 – 1.00	1.00 – 0.50	0.50 – 0.25	0.250 – 0.125	0.1250 – 0.0625	0.0625 – 0.0039	<0.0039	(mm)	(mm)					
ASR 01	0.40	0.49	7.31	62.75	8.30	12.75	8.00	0.00	0.354	0.231	1.070	5.603	(g)S	poorly sorted	strongly fine-skewed
ASR 02	0.00	2.72	54.31	35.10	6.31	1.56	0.00	0.00	0.512	0.475	0.410	1.104	S	well sorted	strongly fine-skewed
ASR 03	0.00	0.00	3.53	83.60	8.69	4.17	0.00	0.00	0.444	0.420	0.398	1.396	S	well sorted	strongly fine-skewed
ASR 04	0.59	1.64	3.27	85.42	4.64	4.45	0.00	0.00	0.435	0.410	0.444	1.203	(g)S	well sorted	strongly fine-skewed
ASR 05	2.40	2.20	49.74	33.94	6.02	2.66	3.04	0.00	0.509	0.470	0.725	3.266	(g)S	moderately sorted	strongly fine-skewed
ASR 06	1.67	0.00	4.82	78.52	14.99	0.00	0.00	0.00	0.376	0.346	0.490	0.707	(g)S	well sorted	strongly fine-skewed
ASR 07	0.26	1.19	1.65	88.14	7.38	1.12	0.26	0.00	0.321	0.311	0.295	0.378	S	very well sorted	strongly fine-skewed
ASR 08	0.06	0.44	9.33	84.91	4.51	0.75	0.00	0.00	0.376	0.363	0.290	0.361	S	very well sorted	strongly fine-skewed
ASR 09	0.00	3.64	13.51	70.99	11.87	0.00	0.00	0.00	0.380	0.358	0.551	0.625	S	moderately well sorted	strongly fine-skewed
ASR 10	1.99	1.37	82.85	10.84	2.33	0.62	0.00	0.00	0.562	0.546	0.362	0.561	S	well sorted	strongly fine-skewed
ASR 11	1.89	1.03	12.16	67.64	13.88	3.38	0.00	0.00	0.365	0.313	0.597	1.754	S	moderately well sorted	strongly fine-skewed
ASR 12	0.00	0.34	4.59	77.96	13.69	3.42	0.00	0.00	0.265	0.249	0.320	0.651	S	very well sorted	strongly fine-skewed
ASR 13	0.27	0.20	2.22	82.72	13.32	1.08	0.20	0.00	0.302	0.280	0.344	0.567	S	very well sorted	strongly fine-skewed
ASR 14	2.73	0.07	0.00	6.48	84.73	6.00	0.00	0.00	0.159	0.155	0.311	-0.043	S	very well sorted	near-symmetrical
ASR 15	0.00	25.10	31.24	37.11	5.53	1.01	0.00	0.00	0.438	0.526	0.852	-0.921	S	moderately sorted	strongly coarse-skewed
ASR 16	1.48	13.96	37.81	43.61	2.25	0.41	0.47	0.00	0.427	0.476	0.729	-1.313	S	moderately sorted	strongly coarse-skewed
ASR 17	0.14	0.07	4.13	74.10	12.53	5.51	3.51	0.00	0.260	0.237	0.516	2.249	S	moderately well sorted	strongly fine-skewed
ASR 18	1.05	1.42	5.49	77.05	14.99	0.00	0.00	0.00	0.312	0.285	0.572	0.834	S	moderately well sorted	strongly fine-skewed
ASR 19	1.10	0.08	4.17	73.51	16.19	1.57	3.38	0.00	0.225	0.218	0.403	0.196	S	well sorted	fine-skewed
ASR 20	0.72	1.43	2.93	73.09	14.75	7.09	0.00	0.00	0.258	0.239	0.679	4.530	S	moderately well sorted	strongly fine-skewed
ASR 21	0.70	0.14	1.47	83.65	14.05	0.00	0.00	0.00	0.313	0.293	1.160	21.797	S	poorly sorted	strongly fine-skewed
ASR 22	0.31	9.66	61.18	22.99	4.61	0.62	0.62	0.00	0.454	0.436	0.555	0.336	S	moderately well sorted	strongly fine-skewed
ASR 23	0.92	0.98	23.69	43.69	9.63	16.60	4.50	0.00	0.341	0.236	1.138	5.292	S	poorly sorted	strongly fine-skewed
ASR 24	0.60	0.07	0.67	76.35	20.44	1.80	0.07	0.00	0.242	0.232	0.330	0.422	S	very well sorted	strongly fine-skewed
ASR 25	0.00	0.00	0.92	58.55	37.20	3.34	0.00	0.00	0.216	0.199	0.337	0.535	S	very well sorted	strongly fine-skewed
ASR 26	2.01	7.41	60.77	29.81	0.00	0.00	0.00	0.00	0.445	0.433	0.421	-1.160	S	well sorted	strongly coarse-skewed
ASR 27	0.00	0.00	2.83	75.81	21.37	0.00	0.00	0.00	0.237	0.231	0.322	0.360	S	very well sorted	strongly fine-skewed
ASR 28	0.00	0.13	3.07	85.95	9.08	1.76	0.00	0.00	0.318	0.301	0.344	0.563	S	very well sorted	strongly fine-skewed
ASR 29	0.00	0.00	28.51	62.10	9.39	0.00	0.00	0.00	0.371	0.353	0.459	0.571	S	well sorted	strongly fine-skewed
ASR 30	0.00	0.00	0.98	57.77	39.15	2.10	0.00	0.00	0.217	0.202	0.381	0.319	S	well sorted	strongly fine-skewed
ASR 31	0.27	0.67	3.47	82.40	13.20	0.00	0.00	0.00	0.272	0.267	0.294	0.232	S	very well sorted	fine-skewed
ASR 32	0.13	0.00	0.79	88.86	9.44	0.66	0.13	0.00	0.328	0.316	0.356	0.482	S	well sorted	strongly fine-skewed
ASR 33	0.60	3.99	59.35	25.55	5.59	0.53	4.39	0.00	0.438	0.396	0.548	2.159	S	moderately well sorted	strongly fine-skewed
ASR 34	1.36	4.33	71.00	15.89	7.42	0.00	0.00	0.00	0.469	0.457	0.548	0.145	S	moderately well sorted	fine-skewed
ASR 35	0.00	11.10	67.68	12.13	9.10	0.00	0.00	0.00	0.555	0.515	1.266	17.330	S	poorly sorted	strongly fine-skewed
ASR 36	0.14	0.27	3.11	60.61	26.55	8.11	1.22	0.00	0.300	0.216	0.891	3.619	S	moderately sorted	strongly fine-skewed
ASR 37	0.78	2.33	2.51	80.39	13.99	0.00	0.00	0.00	0.309	0.286	0.456	0.517	S	well sorted	strongly fine-skewed
ASR 38	0.00	1.27	3.47	84.15	11.11	0.00	0.00	0.00	0.314	0.299	0.422	1.725	S	well sorted	strongly fine-skewed
ASR 39	0.00	1.36	3.03	87.95	7.24	0.42	0.00	0.00	0.330	0.323	0.327	0.329	S	very well sorted	strongly fine-skewed
ASR 40	0.00	0.00	4.54	83.66	11.81	0.00	0.00	0.00	0.314	0.297	0.398	1.371	S	well sorted	strongly fine-skewed
ASR 41	1.07	0.50	1.76	84.44	7.21	3.39	1.63	0.00	0.367	0.332	0.483	1.774	S	well sorted	strongly fine-skewed
ASR 42	2.85	0.00	65.92	26.52	3.90	0.81	0.00	0.00	0.451	0.431	0.383	0.565	S	well sorted	strongly fine-skewed
ASR 43	0.96	0.75	69.15	18.02	4.64	6.48	0.00	0.00	0.496	0.433	1.000	11.615	S	poorly sorted	strongly fine-skewed
ASR 44	0.00	4.17	36.43	19.11	12.08	22.20	6.01	0.00	0.344	0.245	1.316	5.491	zS	poorly sorted	strongly fine-skewed
ASR 45	0.58	0.06	30.51	63.91	4.10	0.71	0.13	0.00	0.390	0.380	0.328	0.376	S	very well sorted	strongly fine-skewed
ASR 46	0.00	0.00	3.73	73.45	19.23	3.59	0.00	0.00	0.264	0.240	0.416	0.714	S	well sorted	strongly fine-skewed
ASR 47	0.27	0.80	6.03	80.09	10.46	0.47	1.88	0.00	0.305	0.287	0.467	0.042	S	well sorted	near-symmetrical
ASR 48	0.13	1.00	0.73	85.98	12.15	0.00	0.00	0.00	0.318	0.298	0.412	1.020	S	well sorted	strongly fine-skewed
ASR 49	0.00	0.00	5.15	64.22	28.58	2.05	0.00	0.00	0.224	0.210	0.378	0.433	S	well sorted	strongly fine-skewed
ASR 50	0.07	0.00	12.51	77.74	9.68	0.00	0.00	0.00	0.377	0.348	0.400	0.896	S	well sorted	strongly fine-skewed
ASR 51	0.14	1.38	3.18	87.55	5.39	0.55	1.80	0.00	0.370	0.348	0.340	0.735	S	very well sorted	strongly fine-skewed
ASR 52	1.00	7.73	28.51	58.43	4.33	0.00	0.00	0.00	0.395	0.387	0.568	-0.481	S	moderately well sorted	strongly coarse-skewed
ASR 53	0.45	1.68	3.49	86.37	8.01	0.00	0.00	0.00	0.371	0.352	0.352	0.499	S	well sorted	strongly fine-skewed
ASR 54	0.99	0.71	2.12	41.16	29.35	18.95	6.72	0.00	0.176	0.138	1.237	10.128	zS	poorly sorted	strongly fine-skewed
ASR 55	0.60	0.00	1.72	86.98	8.61	2.10	0.00	0.00	0.284	0.281	0.300	0.356	S	very well sorted	strongly fine-skewed
ASR 56	3.62	4.51	4.83	55.85	31.18	0.00	0.00	0.00	0.290	0.253	1.253	8.489	S	poorly sorted	strongly fine-skewed
ASR 57	1.99	0.00	0.00	5.48	82.63	9.89	0.00	0.00	0.157	0.150	0.352	0.039	S	well sorted	near-symmetrical
ASR 58	0.74	2.94	54.38	37.32	3.75	0.67	0.20	0.00	0.432	0.410	0.377	0.384	S	well sorted	strongly fine-skewed
ASR 59	0.00	0.16	2.69	86.24	10.91	0.00	0.00	0.00	0.279	0.284	0.414	1.523	S	well sorted	strongly fine-skewed
ASR 60	0.73	0.87	1.60	61.26	13.81	13.59	8.14	0.00	0.264	0.182	1.067	4.937	zS	poorly sorted	strongly fine-skewed
ASR 61	0.00	1.08	3.04	80.25	14.05	1.58	0.00	0.00	0.307	0.281	0.380	0.805	S	well sorted	strongly fine-skewed
ASR 62	0.90	0.83	2.43	48.89	11.74	29.17	6.04	0.00	0.213	0.167	0.722	2.910	zS	moderately sorted	strongly fine-skewed
ASR 63	3.17	4.75	47.52	35.64	5.81	3.10	0.00	0.00	0.429	0.401	0.656	-0.008	S	moderately well sorted	near-symmetrical
ASR 64	1.62	1.69	65.21	28.19	3.30	0.00	0.00	0.00	0.450	0.465	0.462	0.156	S	well sorted	fine-skewed
ASR 65	0.00	2.16	3.29	82.23	5.39	5.74	1.19	0.00	0.362	0.325	0.593	2.444	S	moderately well sorted	strongly fine-skewed

Table 16 Summary Sediment Grain Size Data 2011 (Percentage by Volume)

Site	Size class (mm)								Median Size	Graphic Mean Size	Sorting	Skewness	Characterization		
	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay							
	>2.00	2.00 - 1.00	1.00 - 0.50	0.50 - 0.25	0.250 0.125	0.125 0.0625	0.0625 0.0039	<0.0039	(mm)	(mm)					
A1S03	2.21	11.30	49.08	32.69	3.55	1.07	0.09	0.00	0.585	0.584	0.720	-0.004	(g)S	moderately sorted	near-symmetrical
A1S04	2.85	5.26	42.79	41.43	6.92	0.51	0.24	0.00	0.506	0.504	0.716	-0.001	(g)S	moderately sorted	near-symmetrical
A1S05	1.85	3.20	43.41	46.67	4.88	0.00	0.00	0.00	0.492	0.493	0.615	-0.065	(g)S	moderately well sorted	near-symmetrical
A1S06	3.03	5.30	44.52	41.10	5.26	0.00	0.80	0.00	0.517	0.516	0.692	-0.044	(g)S	moderately well sorted	near-symmetrical
A1S07	1.56	5.08	41.39	43.60	8.32	0.04	0.00	0.00	0.488	0.488	0.701	-0.006	(g)S	moderately well sorted	near-symmetrical
A1S08	2.58	9.31	49.24	34.80	3.03	0.92	0.13	0.00	0.571	0.573	0.696	-0.073	(g)S	moderately well sorted	near-symmetrical
A1S10	32.98	12.14	25.58	13.98	4.71	1.63	7.93	1.05	0.871	0.869	2.044	14.573	msG	very poorly sorted	strongly fine-skewed
A1S11	0.92	6.68	44.52	41.56	6.32	0.00	0.00	0.00	0.513	0.511	0.686	0.019	(g)S	moderately well sorted	near-symmetrical
A1S12	1.76	3.40	38.22	46.34	10.24	0.04	0.00	0.00	0.461	0.460	0.695	-0.006	(g)S	moderately well sorted	near-symmetrical
A1S13	8.20	9.32	39.58	34.98	6.62	0.07	1.23	0.00	0.555	0.568	0.983	-1.683	gS	moderately sorted	strongly coarse-skewed
A1S14	4.96	8.98	34.64	37.35	12.34	0.39	1.34	0.00	0.489	0.494	0.990	-1.007	(g)S	moderately sorted	strongly coarse-skewed
A1S15	23.54	7.85	35.25	26.98	3.69	0.65	2.03	0.00	0.664	0.837	1.303	-3.010	gS	poorly sorted	strongly coarse-skewed
A1S16	12.72	12.84	45.20	27.69	1.54	0.00	0.00	0.00	0.667	0.717	0.953	-2.024	gS	moderately sorted	strongly coarse-skewed
A1S17	11.75	4.36	35.37	37.78	7.95	0.29	2.47	0.04	0.511	0.529	1.057	-2.314	gS	poorly sorted	strongly coarse-skewed
A1S18	30.96	7.25	29.73	25.87	4.22	0.15	1.81	0.00	0.720	0.892	1.347	-2.700	sG	poorly sorted	strongly coarse-skewed
A1S19	16.42	0.74	18.50	40.75	20.53	0.88	2.18	0.00	0.388	0.494	1.345	-4.688	gS	poorly sorted	strongly coarse-skewed
A1S20	3.75	1.98	35.64	47.89	10.74	0.00	0.00	0.00	0.450	0.451	0.707	-0.198	(g)S	moderately well sorted	coarse-skewed
A1S21	2.60	10.47	48.39	35.85	2.69	0.00	0.00	0.00	0.575	0.581	0.698	-0.235	(g)S	moderately well sorted	coarse-skewed
A1S22	19.53	17.71	37.65	18.48	3.67	0.96	2.00	0.00	0.788	0.890	1.241	-0.959	gS	poorly sorted	strongly coarse-skewed
A1S23	6.22	18.84	49.72	24.28	0.93	0.00	0.00	0.00	0.698	0.712	0.808	-0.891	gS	moderately sorted	strongly coarse-skewed
A1S24	1.66	2.06	35.01	48.47	12.71	0.09	0.00	0.00	0.434	0.432	0.694	0.024	(g)S	moderately well sorted	near-symmetrical
A1S25	1.81	0.10	18.23	50.78	27.97	1.10	0.00	0.00	0.328	0.331	0.706	-0.142	(g)S	moderately well sorted	coarse-skewed
A1S26	23.22	5.76	29.06	32.83	9.05	0.07	0.00	0.00	0.581	0.757	1.369	-3.992	gS	poorly sorted	strongly coarse-skewed
A1S27	2.09	0.20	24.90	52.88	19.75	0.18	0.00	0.00	0.373	0.373	0.676	-0.057	(g)S	moderately well sorted	near-symmetrical
A1S28	8.52	12.76	47.05	29.35	2.32	0.00	0.00	0.00	0.639	0.657	0.883	-1.551	gS	moderately sorted	strongly coarse-skewed
A1S29	1.02	6.61	42.28	41.96	8.08	0.06	0.00	0.00	0.499	0.498	0.714	0.024	(g)S	moderately sorted	near-symmetrical
A1S30	27.80	0.04	7.83	35.60	25.39	1.36	1.93	0.05	0.358	0.519	1.524	-6.767	gS	poorly sorted	strongly coarse-skewed
A1S31	3.81	8.57	44.48	38.05	5.09	0.00	0.00	0.00	0.546	0.550	0.751	-0.347	(g)S	moderately sorted	strongly coarse-skewed
A1S32	2.10	14.76	48.91	31.10	3.13	0.00	0.00	0.00	0.614	0.615	0.732	-0.089	(g)S	moderately sorted	near-symmetrical
A1S33	28.93	13.96	33.11	19.24	3.48	0.37	0.92	0.00	0.850	0.981	1.262	-1.461	gS	poorly sorted	strongly coarse-skewed
A1S34	9.96	18.48	44.55	23.96	2.59	0.39	0.07	0.00	0.709	0.730	0.945	-1.207	gS	moderately sorted	strongly coarse-skewed
A1S35	8.02	20.77	49.00	21.56	0.64	0.00	0.00	0.00	0.737	0.757	0.841	-1.077	gS	moderately sorted	strongly coarse-skewed
A1S36	2.71	4.58	34.06	43.13	14.94	0.58	0.00	0.00	0.442	0.442	0.809	-0.104	(g)S	moderately sorted	coarse-skewed
A1S37	18.18	3.45	26.34	37.47	14.10	0.47	0.00	0.00	0.483	0.647	1.402	-4.812	gS	poorly sorted	strongly coarse-skewed
A1S38	5.15	7.16	42.51	40.03	5.17	0.00	0.00	0.00	0.532	0.541	0.832	-1.326	gS	moderately sorted	strongly coarse-skewed
A1S39	20.31	5.32	26.78	34.02	13.16	0.40	0.00	0.00	0.525	0.686	1.417	-4.278	gS	poorly sorted	strongly coarse-skewed
A1S40	2.86	2.68	39.45	46.06	8.95	0.00	0.00	0.00	0.470	0.470	0.686	-0.039	(g)S	moderately well sorted	near-symmetrical
A1S41	6.85	17.57	43.72	26.36	4.43	0.40	0.68	0.00	0.660	0.665	0.940	-0.707	gS	moderately sorted	strongly coarse-skewed
A1S42	2.73	18.17	50.32	26.90	1.88	0.00	0.00	0.00	0.662	0.666	0.731	-0.168	(g)S	moderately sorted	coarse-skewed
A1S43	17.48	16.72	35.28	21.82	4.20	0.55	3.73	0.21	0.728	0.811	1.319	-0.531	gS	poorly sorted	strongly coarse-skewed
A1S44	7.69	20.36	48.27	22.57	1.11	0.00	0.00	0.00	0.725	0.743	0.850	-1.027	gS	moderately sorted	strongly coarse-skewed
A1S45	24.84	10.73	33.70	25.04	5.15	0.43	0.11	0.00	0.718	0.873	1.292	-2.519	gS	poorly sorted	strongly coarse-skewed
A1S46	11.43	0.15	13.79	43.60	29.37	1.67	0.00	0.00	0.328	0.350	1.055	-3.622	gS	poorly sorted	strongly coarse-skewed
A1S47	44.78	6.82	24.58	20.56	3.25	0.00	0.00	0.00	1.088	1.115	1.302	0.255	sG	poorly sorted	fine-skewed
A1S48	11.37	3.48	27.88	40.07	16.46	0.73	0.00	0.00	0.444	0.468	1.114	-3.023	gS	poorly sorted	strongly coarse-skewed
A1S49	32.76	7.15	26.78	25.18	6.22	0.14	1.77	0.00	0.731	0.882	1.401	-2.264	sG	poorly sorted	strongly coarse-skewed
A1S50	10.89	18.81	46.51	21.38	0.99	0.00	1.41	0.00	0.734	0.762	0.918	-1.307	gS	moderately sorted	strongly coarse-skewed
A1S52	1.30	11.78	54.30	31.69	0.93	0.00	0.00	0.00	0.608	0.612	0.630	-0.133	(g)S	moderately well sorted	coarse-skewed
A1S53	1.64	9.69	40.84	36.98	10.28	0.57	0.00	0.00	0.516	0.510	0.824	0.147	(g)S	moderately sorted	fine-skewed
A1S54	13.92	5.22	32.57	37.63	10.52	0.13	0.00	0.00	0.514	0.559	1.114	-2.859	gS	poorly sorted	strongly coarse-skewed
A1S55	1.04	8.09	42.30	40.61	7.91	0.04	0.00	0.00	0.510	0.509	0.733	0.001	(g)S	moderately sorted	near-symmetrical
A1S56	3.02	19.84	51.50	24.43	1.21	0.00	0.00	0.00	0.689	0.694	0.718	-0.161	(g)S	moderately sorted	coarse-skewed
A1S57	0.51	0.00	6.06	42.31	45.09	6.03	0.00	0.00	0.247	0.248	0.668	-0.105	(g)S	moderately well sorted	coarse-skewed
A1S58	25.24	12.08	35.26	24.35	3.07	0.00	0.00	0.00	0.756	0.915	1.233	-2.493	gS	poorly sorted	strongly coarse-skewed
A1S59	13.08	5.83	38.20	35.64	6.61	0.40	0.24	0.00	0.554	0.586	1.035	-2.421	gS	poorly sorted	strongly coarse-skewed
A1S60	12.00	2.18	32.50	43.18	10.14	0.00	0.00	0.00	0.478	0.501	0.975	-2.472	gS	moderately sorted	strongly coarse-skewed
A1S61	1.48	1.35	30.86	48.50	15.92	0.33	1.57	0.00	0.404	0.401	0.734	0.149	(g)S	moderately sorted	fine-skewed
A1S62	0.42	0.28	20.07	48.65	28.39	2.19	0.00	0.00	0.327	0.327	0.736	-0.007	(g)S	moderately sorted	near-symmetrical
A1S63	0.56	0.68	6.80	38.33	45.93	7.71	0.00	0.00	0.239	0.243	0.714	-0.301	(g)S	moderately sorted	strongly coarse-skewed
A2S01	8.30	19.64	51.72	20.10	0.24	0.00	0.00	0.00	0.740	0.762	0.810	-1.205	gS	moderately sorted	strongly coarse-skewed
A2S04	1.12	6.63	52.66	38.30	1.30	0.00	0.00	0.00	0.557	0.558	0.583	-0.098	(g)S	moderately well sorted	near-symmetrical
A2S05	3.70	14.99	52.73	27.83	0.75	0.00	0.00	0.00	0.649	0.659	0.699	-0.376	(g)S	moderately well sorted	strongly coarse-skewed
A2S07	12.77	22.51	45.57	17.09	1.42	0.64	0.00	0.00	0.802	0.842	0.934	-1.201	gS	moderately sorted	strongly coarse-skewed
A2S08	15.09	16.84	41.11	18.94	3.25	1.11	3.54	0.12	0.734	0.790	1.246	0.406	gS	poorly sorted	strongly fine-skewed
A2S09	14.89	10.19	40.07	27.43	4.75	1.00	1.67	0.00	0.632	0.698	1.145	-1.855	gS	poorly sorted	strongly coarse-skewed
A2S10	6.03	15.72	44.59	24.75	4.58	1.15	2.93	0.24	0.639	0.631	1.029	0.576	gS	poorly sorted	strongly fine-skewed
A2S11	20.91	17.65	39.31	16.46	1.98	0.88	2.71	0.11	0.813	0.937	1.215	-1.043	gS	poorly sorted	strongly coarse-skewed
A2S12	9.61	23.93	50.73	15.70	0.03	0.00	0.00	0.00	0.803	0.829	0.809	-1.131	gS	moderately sorted	strongly coarse-skewed
A2S13	4.87	14.98	52.26	26.94	0.95	0.00	0.00	0.00	0.658	0.669	0.747	-0.711	(g)S	moderately sorted	strongly coarse-skewed

Site	Size class (mm)								Median Size	Graphic Mean Size	Sorting	Skewness	Characterization		
	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay							
	>2.00	2.00 -1.00	1.00 -0.50	0.50 -0.25	0.250 0.125	0.125 0.0625	0.0625 0.0039	<0.0039	(mm)	(mm)					
A2S14	47.68	5.90	23.33	19.63	3.06	0.00	0.40	0.00	1.270	1.186	1.304	1.689	sG	poorly sorted	strongly fine-skewed
A2S15	0.60	16.73	54.01	26.62	0.90	0.00	1.14	0.00	0.649	0.649	0.663	0.012	(g)S	moderately well sorted	near-symmetrical
A2S16	22.75	22.71	36.34	13.56	3.02	0.63	0.99	0.00	0.924	1.019	1.163	-0.631	gS	poorly sorted	strongly coarse-skewed
A2S17	15.21	14.18	41.83	22.73	1.95	0.86	3.07	0.17	0.697	0.774	1.137	-1.447	gS	poorly sorted	strongly coarse-skewed
A2S18	1.28	11.22	56.01	30.94	0.54	0.00	0.00	0.00	0.611	0.616	0.607	-0.131	(g)S	moderately well sorted	coarse-skewed
A2S19	5.68	9.35	40.30	36.73	7.85	0.09	0.00	0.00	0.539	0.546	0.915	-1.228	gS	moderately sorted	strongly coarse-skewed
A2S20	8.97	16.62	46.81	22.67	1.15	0.85	2.82	0.11	0.688	0.704	0.938	-0.990	gS	moderately sorted	strongly coarse-skewed
A2S21	17.34	22.53	35.55	11.44	2.62	1.50	8.42	0.61	0.837	0.848	1.803	13.822	gmS	poorly sorted	strongly fine-skewed
A2S22	46.86	11.47	16.35	8.70	6.79	2.07	6.51	1.24	1.465	1.030	2.108	22.411	msG	very poorly sorted	strongly fine-skewed
A2S23	23.28	22.94	37.91	9.73	0.69	0.93	4.25	0.28	0.939	1.053	1.353	2.914	gS	poorly sorted	strongly fine-skewed
A2S24	16.45	19.26	42.13	17.20	1.35	0.91	2.59	0.11	0.788	0.887	1.117	-1.289	gS	poorly sorted	strongly coarse-skewed
A2S25	9.34	16.50	45.26	24.46	2.38	0.72	1.34	0.00	0.681	0.700	0.950	-1.165	gS	moderately sorted	strongly coarse-skewed
A2S26	12.68	6.08	41.97	35.54	3.73	0.00	0.00	0.00	0.576	0.611	0.958	-2.441	gS	moderately sorted	strongly coarse-skewed
A2S27	2.34	12.92	49.48	32.94	2.32	0.00	0.00	0.00	0.600	0.605	0.703	-0.185	(g)S	moderately well sorted	coarse-skewed
A2S28	13.52	19.00	42.53	18.03	1.13	0.70	4.74	0.36	0.753	0.787	1.374	4.784	gS	poorly sorted	strongly fine-skewed
A2S29	12.94	22.03	47.11	17.57	0.35	0.00	0.00	0.00	0.801	0.850	0.902	-1.428	gS	moderately sorted	strongly coarse-skewed
A2S30	0.35	0.28	7.38	33.88	43.42	9.53	4.72	0.43	0.223	0.225	1.019	2.586	(g)S	poorly sorted	strongly fine-skewed
A2S31	0.10	0.65	9.42	34.24	41.87	9.88	3.57	0.27	0.230	0.233	0.857	-0.115	(g)S	moderately sorted	coarse-skewed
A2S33	11.98	9.56	28.28	23.45	5.49	1.82	16.39	3.02	0.498	0.271	2.701	24.245	gmS	very poorly sorted	strongly fine-skewed
A2S34	11.85	8.80	40.69	33.08	4.94	0.46	0.19	0.00	0.588	0.619	1.001	-2.123	gS	poorly sorted	strongly coarse-skewed
A2S35	2.54	11.67	47.87	35.11	2.81	0.00	0.00	0.00	0.581	0.587	0.713	-0.243	(g)S	moderately sorted	coarse-skewed
A2S36	13.00	16.32	41.94	21.63	3.35	1.03	2.63	0.10	0.703	0.736	1.119	-0.574	gS	poorly sorted	strongly coarse-skewed
A2S37	1.98	4.73	23.44	37.02	25.38	3.76	3.45	0.24	0.342	0.346	1.032	-0.015	(g)S	poorly sorted	near-symmetrical
A2S38	9.18	8.86	27.96	24.19	13.00	3.68	11.18	1.95	0.454	0.384	2.059	13.680	gmS	very poorly sorted	strongly fine-skewed
A2S39	8.78	16.76	47.66	22.71	2.73	1.34	0.01	0.00	0.693	0.709	0.912	-1.064	gS	moderately sorted	strongly coarse-skewed
A2S40	5.01	11.25	49.04	31.12	2.80	0.77	0.01	0.00	0.607	0.610	0.801	-0.801	gS	moderately sorted	strongly coarse-skewed
A2S41	5.66	7.31	51.08	34.68	1.27	0.00	0.00	0.00	0.584	0.594	0.757	-1.374	gS	moderately sorted	strongly coarse-skewed
A2S42	2.81	21.38	51.95	21.77	1.13	0.95	0.01	0.00	0.707	0.709	0.717	-0.060	(g)S	moderately sorted	near-symmetrical
A2S43	2.91	21.67	55.12	20.25	0.05	0.00	0.00	0.00	0.725	0.731	0.663	-0.200	(g)S	moderately well sorted	coarse-skewed
A2S44	0.71	0.05	5.21	36.37	45.95	7.40	3.95	0.36	0.227	0.227	0.753	0.169	(g)S	moderately sorted	fine-skewed
A2S45	5.16	19.29	55.04	20.47	0.03	0.00	0.00	0.00	0.719	0.731	0.714	-0.689	gS	moderately sorted	strongly coarse-skewed
A2S46	5.22	14.10	52.80	27.13	0.75	0.00	0.00	0.00	0.654	0.667	0.751	-0.886	gS	moderately sorted	strongly coarse-skewed
A2S47	5.04	15.18	51.11	26.22	1.48	0.97	0.01	0.00	0.657	0.664	0.778	-0.690	gS	moderately sorted	strongly coarse-skewed
A2S48	7.18	12.20	45.83	32.17	2.61	0.00	0.00	0.00	0.613	0.630	0.872	-1.457	gS	moderately sorted	strongly coarse-skewed
A2S49	3.23	9.48	48.15	34.11	4.13	0.83	0.07	0.00	0.572	0.572	0.728	-0.075	(g)S	moderately sorted	near-symmetrical
A2S50	3.66	16.96	48.47	21.75	2.22	1.52	5.04	0.37	0.655	0.640	1.214	7.289	(g)S	poorly sorted	strongly fine-skewed
A2S51	1.78	16.65	51.83	26.09	2.31	1.34	0.01	0.00	0.648	0.646	0.719	0.094	(g)S	moderately sorted	near-symmetrical
A2S52	8.41	6.42	48.68	34.55	1.95	0.00	0.00	0.00	0.587	0.597	0.811	-1.567	gS	moderately sorted	strongly coarse-skewed
A2S53	7.14	11.82	45.28	30.75	4.28	0.71	0.01	0.00	0.608	0.618	0.902	-1.275	gS	moderately sorted	strongly coarse-skewed
A2S54	9.64	5.77	42.21	35.75	5.87	0.67	0.09	0.00	0.553	0.562	0.946	-1.966	gS	moderately sorted	strongly coarse-skewed
A2S55	4.32	3.40	45.94	42.14	4.19	0.00	0.00	0.00	0.521	0.522	0.656	-0.149	(g)S	moderately well sorted	coarse-skewed
A2S56	1.22	7.21	51.39	37.54	2.65	0.00	0.00	0.00	0.558	0.557	0.624	0.021	(g)S	moderately well sorted	near-symmetrical
A2S57	2.96	16.15	52.97	23.95	2.47	1.48	0.01	0.00	0.661	0.660	0.727	0.088	(g)S	moderately sorted	near-symmetrical
A2S58	1.32	17.85	51.83	22.47	4.17	2.35	0.01	0.00	0.660	0.648	0.802	0.957	(g)S	moderately sorted	strongly fine-skewed
A2S59	1.44	1.96	10.28	33.87	40.88	8.50	2.92	0.16	0.241	0.250	0.913	-0.792	(g)S	moderately sorted	strongly coarse-skewed
A2S61	2.48	8.35	47.24	36.69	4.45	0.60	0.18	0.00	0.552	0.551	0.709	-0.021	(g)S	moderately well sorted	near-symmetrical
A2S63	15.65	22.75	45.61	14.56	0.63	0.80	0.00	0.00	0.841	0.934	0.966	-1.568	gS	moderately sorted	strongly coarse-skewed
A2S65	34.36	17.11	24.82	6.49	2.15	1.81	11.35	1.92	1.039	0.790	2.342	24.138	msG	very poorly sorted	strongly fine-skewed
A2S66	17.54	15.03	39.77	22.73	2.34	0.53	2.02	0.04	0.724	0.844	1.174	-2.020	gS	poorly sorted	strongly coarse-skewed
A2S68	23.33	12.74	38.89	23.28	1.77	0.00	0.00	0.00	0.758	0.925	1.172	-2.626	gS	poorly sorted	strongly coarse-skewed
A2S69	18.42	22.20	34.52	12.78	2.88	1.25	7.16	0.80	0.839	0.870	1.822	14.250	gS	poorly sorted	strongly fine-skewed
A2S70	3.39	0.22	2.95	28.32	48.75	10.01	5.67	0.70	0.206	0.207	1.094	4.044	(g)S	poorly sorted	strongly fine-skewed
A2S71	19.88	18.87	41.57	17.20	1.73	0.75	0.00	0.00	0.825	0.953	1.098	-1.802	gS	poorly sorted	strongly coarse-skewed
A2S72	12.72	12.32	39.48	25.69	5.67	1.08	2.92	0.11	0.634	0.656	1.177	-0.630	gS	poorly sorted	strongly coarse-skewed
A2S73	25.65	13.61	38.24	21.29	1.21	0.00	0.00	0.00	0.805	0.970	1.168	-2.371	gS	poorly sorted	strongly coarse-skewed
A2S74	14.48	18.94	44.20	17.74	1.95	1.03	1.65	0.00	0.769	0.825	1.032	-1.142	gS	poorly sorted	strongly coarse-skewed
A2S75	0.02	1.29	4.76	30.93	49.46	8.66	4.50	0.39	0.213	0.214	0.788	0.156	(g)S	moderately sorted	fine-skewed
A2S76	10.61	18.00	46.89	21.13	2.54	0.83	0.00	0.00	0.724	0.749	0.928	-1.214	gS	moderately sorted	strongly coarse-skewed
A2S77	9.41	16.66	43.13	21.62	4.23	1.48	3.36	0.11	0.677	0.678	1.143	0.857	gS	poorly sorted	strongly fine-skewed
A2S78	6.66	12.69	48.09	30.75	1.81	0.00	0.00	0.00	0.627	0.641	0.835	-1.321	gS	moderately sorted	strongly coarse-skewed
A2S79	2.13	14.03	52.49	28.83	1.67	0.85	0.01	0.00	0.628	0.627	0.684	-0.051	(g)S	moderately well sorted	near-symmetrical
A2S80	20.81	29.86	41.22	6.28	0.00	0.00	1.84	0.00	1.010	1.127	0.937	-1.262	gS	moderately sorted	strongly coarse-skewed
A2S82	1.26	3.16	38.26	47.01	10.29	0.00	0.00	0.00	0.457	0.456	0.683	0.012	(g)S	moderately well sorted	near-symmetrical
A2S83	4.70	5.10	42.02	42.07	6.10	0.00	0.00	0.00	0.512	0.515	0.742	-0.456	(g)S	moderately sorted	strongly coarse-skewed
A2S84	7.69	27.68	49.94	13.60	0.02	0.00	1.08	0.00	0.826	0.840	0.782	-0.737	gS	moderately sorted	strongly coarse-skewed
A2S85	13.12	19.70	41.75	17.95	3.07	1.08	3.13	0.19	0.754	0.779	1.163	0.503	gS	poorly sorted	strongly fine-skewed
A2S86	4.49	16.53	48.77	26.78	2.55	0.87	0.01	0.00	0.653	0.658	0.799	-0.375	(g)S	moderately sorted	strongly coarse-skewed
A2S87	7.29	15.30	50.86	25.94	0.62	0.00	0.00	0.00	0.674	0.693	0.812	-1.284	gS	moderately sorted	strongly coarse-skewed
A2S89	1.39	11.77	58.98	27.71	0.15	0.00	0.00	0.00	0.632	0.637	0.583	-0.124	(g)S	moderately well sorted	coarse-skewed
CTS1.00	0.99	0.93	37.58	51.07	9.42	0.00	0.00	0.00	0.444	0.442	0.622	0.053	(g)S	moderately well sorted	near-symmetrical
CTS1.01	2.32	4.92	49.68	37.77	1.88	0.51	2.86	0.06	0.539	0.536	0.647	0.143	(g)S	moderately well sorted	fine-skewed
CTS1.02	3.89	3.71	41.74	43.69	6.97	0.00	0.00	0.00	0.496	0.497	0.701	-0.153	(g)S	moderately well sorted	coarse-skewed

Site	Gravel >2.00	Very Coarse Sand 2.00 - 1.00	Coarse Sand 1.00 - 0.50	Medium Sand 0.50 - 0.25	Fine Sand 0.250 0.125	Very Fine Sand 0.125 0.0625	Silt 0.0625 0.0039	Clay <0.0039	Median Size (mm)	Graphic Mean Size (mm)	Sorting	Skewness	Characterization		
	Size class (mm)														
CTS1.03	3.69	4.57	43.93	42.17	5.63	0.00	0.00	0.00	0.514	0.514	0.688	-0.132	(g)S	moderately well sorted	coarse-skewed
CTS1.04	0.38	6.02	49.60	40.49	3.52	0.00	0.00	0.00	0.535	0.532	0.620	0.060	(g)S	moderately well sorted	near-symmetrical
CTS1.05	10.17	11.75	46.44	29.84	1.81	0.00	0.00	0.00	0.640	0.664	0.899	-1.817	gS	moderately sorted	strongly coarse-skewed
CTS1.06	9.55	12.11	47.54	28.96	1.83	0.00	0.00	0.00	0.646	0.665	0.884	-1.686	gS	moderately sorted	strongly coarse-skewed
CTS1.07	28.74	6.11	33.57	27.98	3.60	0.00	0.00	0.00	0.691	0.886	1.286	-3.384	gS	poorly sorted	strongly coarse-skewed
CTS1.08	3.17	6.26	47.94	38.83	3.81	0.00	0.00	0.00	0.545	0.545	0.666	-0.061	(g)S	moderately well sorted	near-symmetrical
CTS1.09	12.42	15.41	47.41	23.65	1.11	0.00	0.00	0.00	0.711	0.752	0.920	-1.703	gS	moderately sorted	strongly coarse-skewed
CTS1.10	12.22	4.32	33.69	39.65	10.06	0.06	0.00	0.00	0.502	0.530	1.044	-2.770	gS	poorly sorted	strongly coarse-skewed
CTS1.11	0.21	0.79	7.21	37.65	46.15	8.00	0.00	0.00	0.237	0.242	0.721	-0.335	(g)S	moderately sorted	strongly coarse-skewed
CTS2.00	1.93	0.00	22.59	55.74	14.76	0.04	4.62	0.31	0.370	0.365	0.822	2.043	(g)S	moderately sorted	strongly fine-skewed
CTS2.01	2.74	0.37	31.02	52.40	13.47	0.00	0.00	0.00	0.413	0.414	0.661	-0.052	(g)S	moderately well sorted	near-symmetrical
CTS2.02	1.28	0.49	32.01	52.81	13.41	0.00	0.00	0.00	0.413	0.412	0.643	0.032	(g)S	moderately well sorted	near-symmetrical
CTS2.03	1.03	0.65	35.58	51.35	11.40	0.00	0.00	0.00	0.431	0.429	0.635	0.071	(g)S	moderately well sorted	near-symmetrical
CTS2.04	1.70	0.49	33.01	52.08	12.72	0.00	0.00	0.00	0.420	0.419	0.646	0.034	(g)S	moderately well sorted	near-symmetrical
CTS2.05	28.87	2.73	30.23	32.45	5.72	0.00	0.00	0.00	0.615	0.797	1.305	-3.800	gS	poorly sorted	strongly coarse-skewed
CTS2.06	25.81	3.51	34.06	32.49	4.13	0.00	0.00	0.00	0.620	0.798	1.247	-3.688	gS	poorly sorted	strongly coarse-skewed
CTS2.07	5.99	5.18	43.59	40.01	5.24	0.00	0.00	0.00	0.531	0.535	0.810	-1.170	gS	moderately sorted	strongly coarse-skewed
CTS2.08	2.53	2.02	38.54	47.59	9.31	0.00	0.00	0.00	0.460	0.460	0.668	-0.009	(g)S	moderately well sorted	near-symmetrical
CTS2.09	0.28	0.40	30.57	52.51	16.12	0.12	0.00	0.00	0.398	0.396	0.654	0.098	(g)S	moderately well sorted	near-symmetrical
CTS2.10	0.66	1.26	37.41	50.37	10.30	0.00	0.00	0.00	0.442	0.439	0.635	0.070	(g)S	moderately well sorted	near-symmetrical
CTS2.11	0.62	1.49	45.42	48.78	3.69	0.00	0.00	0.00	0.488	0.485	0.556	0.031	(g)S	moderately well sorted	near-symmetrical
CTS2.12	0.63	4.92	49.04	42.13	3.28	0.00	0.00	0.00	0.526	0.525	0.606	0.039	(g)S	moderately well sorted	near-symmetrical

Table 17 Summary Sediment Grain Size Data 2017 *(Percentage by Volume)*

Site	Gravel >2.00	Very Coarse Sand 2.00–1.00	Coarse Sand 1.00–0.50	Medium Sand 0.50–0.25	Fine Sand 0.250–0.125	Very Fine Sand 0.1250–0.0625	Silt 0.0625–0.0039	Clay <0.0039	Median Size (mm)	Graphic Mean Size (mm)	Sorting	Skewness	Characterization		
	Size class (mm)														
TN W	0.00	1.04	17.99	50.75	27.56	0.96	1.70	0.00	0.322	0.325	0.712	-0.064	S	moderately sorted	near-symmetrical
TN M	0.00	4.90	48.71	39.02	6.30	1.07	0.00	0.00	0.522	0.511	0.663	0.405	S	moderately well sorted	strongly fine-skewed
TN E	0.00	18.16	57.24	22.35	1.52	0.73	0.00	0.00	0.678	0.673	0.628	0.177	S	moderately well sorted	fine-skewed
T0 W	0.00	2.75	38.15	46.54	10.54	0.31	1.71	0.00	0.447	0.439	0.701	0.283	S	moderately well sorted	fine-skewed
T0 0	0.00	0.76	34.17	51.71	12.24	0.18	0.94	0.00	0.420	0.416	0.650	0.189	S	moderately well sorted	fine-skewed
T0 1	0.00	1.81	37.70	50.35	9.81	0.13	0.20	0.00	0.444	0.440	0.635	0.092	S	moderately well sorted	near-symmetrical
T0 2	0.00	0.92	32.97	49.92	15.21	0.42	0.56	0.00	0.410	0.406	0.684	0.225	S	moderately well sorted	fine-skewed
T0 3	0.00	6.22	44.72	39.08	7.00	0.96	1.91	0.11	0.506	0.495	0.742	0.574	S	moderately sorted	strongly fine-skewed
T0 4	0.00	8.08	47.38	34.03	8.41	1.03	1.07	0.00	0.538	0.516	0.776	0.848	S	moderately sorted	strongly fine-skewed
T0 5	1.52	20.70	48.97	22.68	4.06	0.81	1.26	0.00	0.674	0.665	0.818	0.587	(g)S	moderately sorted	strongly fine-skewed
T0 E	0.00	17.57	50.44	24.88	5.61	0.66	0.84	0.00	0.643	0.623	0.777	0.835	S	moderately sorted	strongly fine-skewed
T1 W	0.04	3.93	26.26	49.74	19.76	0.27	0.00	0.00	0.383	0.387	0.742	-0.264	(g)S	moderately sorted	coarse-skewed
T1 M	0.06	9.08	39.12	38.87	9.34	0.78	2.62	0.13	0.488	0.480	0.842	0.516	(g)S	moderately sorted	strongly fine-skewed
T1 E	0.00	17.17	47.24	23.39	5.27	1.16	5.25	0.52	0.623	0.580	1.248	8.706	S	poorly sorted	strongly fine-skewed
T2 W	0.00	1.85	22.19	51.80	23.38	0.51	0.27	0.00	0.354	0.356	0.704	-0.102	S	moderately well sorted	coarse-skewed
T2 0	0.00	0.06	12.83	50.20	30.15	1.57	4.63	0.56	0.292	0.290	0.896	2.439	S	moderately sorted	strongly fine-skewed
T2 1	0.12	1.43	18.35	52.54	25.80	0.60	1.16	0.00	0.332	0.336	0.690	-0.112	(g)S	moderately well sorted	coarse-skewed
T2 2	0.00	0.56	29.31	51.20	15.91	0.39	2.49	0.14	0.391	0.385	0.707	0.360	S	moderately well sorted	strongly fine-skewed
T2 3	0.00	3.10	39.64	46.85	9.19	0.26	0.96	0.00	0.458	0.453	0.673	0.150	S	moderately well sorted	fine-skewed
T2 4	0.00	9.99	40.52	33.82	10.04	1.41	3.91	0.31	0.504	0.481	0.974	1.966	S	moderately sorted	strongly fine-skewed
T2 5	5.19	28.46	41.73	14.46	3.51	1.25	5.03	0.37	0.777	0.748	1.309	7.545	gS	poorly sorted	strongly fine-skewed
T2 E	2.03	21.24	43.68	23.45	6.66	0.73	2.10	0.11	0.659	0.633	0.943	1.141	(g)S	moderately sorted	strongly fine-skewed
T3 W	0.00	0.00	8.88	50.01	37.86	1.94	1.31	0.00	0.275	0.277	0.637	-0.036	S	moderately well sorted	near-symmetrical
T3 M	0.00	2.42	36.72	48.23	12.46	0.17	0.00	0.00	0.438	0.433	0.682	0.146	S	moderately well sorted	fine-skewed
T3 E	0.00	16.89	51.59	27.81	3.18	0.53	0.00	0.00	0.638	0.629	0.702	0.281	S	moderately well sorted	fine-skewed
T4 W	0.00	0.00	23.53	56.53	19.42	0.15	0.37	0.00	0.367	0.364	0.621	0.113	S	moderately well sorted	fine-skewed
T4 0	0.00	0.31	23.30	52.10	23.23	0.69	0.37	0.00	0.355	0.354	0.689	0.085	S	moderately well sorted	near-symmetrical
T4 1	0.37	2.49	18.84	49.94	26.36	0.85	1.15	0.00	0.333	0.338	0.741	-0.266	(g)S	moderately sorted	coarse-skewed
T4 2	0.00	0.82	18.01	49.84	29.76	1.21	0.36	0.00	0.317	0.322	0.707	-0.175	S	moderately well sorted	coarse-skewed
T4 3	0.00	10.62	45.49	33.14	6.57	1.00	3.06	0.12	0.546	0.527	0.843	1.173	S	moderately sorted	strongly fine-skewed
T4 4	0.00	14.94	44.05	29.91	8.04	1.08	1.98	0.00	0.577	0.551	0.882	1.061	S	moderately sorted	strongly fine-skewed
T4 5	0.20	15.37	37.23	30.28	9.78	1.34	5.34	0.46	0.526	0.501	1.289	6.185	(g)S	poorly sorted	strongly fine-skewed
T4 E	2.32	20.43	41.86	23.31	6.74	1.27	3.74	0.33	0.641	0.606	1.074	2.419	(g)S	poorly sorted	strongly fine-skewed
T5 W	0.00	3.17	38.39	46.24	11.51	0.29	0.40	0.00	0.450	0.444	0.699	0.199	S	moderately well sorted	fine-skewed
T5 M	0.00	12.72	51.37	30.59	4.72	0.60	0.00	0.00	0.602	0.591	0.697	0.403	S	moderately well sorted	strongly fine-skewed
T5 E	0.64	20.57	44.05	29.69	4.83	0.11	0.11	0.00	0.631	0.633	0.811	0.046	(g)S	moderately sorted	near-symmetrical
T6 W	0.00	0.00	5.63	48.62	42.32	2.38	1.05	0.00	0.261	0.262	0.604	-0.001	S	moderately well sorted	near-symmetrical
T6 0	0.12	3.39	19.91	47.15	25.70	1.06	2.53	0.14	0.335	0.339	0.809	-0.199	(g)S	moderately sorted	coarse-skewed
T6 1	0.63	6.13	24.56	43.61	23.72	1.00	0.35	0.00	0.370	0.381	0.866	-0.595	(g)S	moderately sorted	strongly coarse-skewed
T6 2	0.40	2.64	19.27	48.79	27.30	1.13	0.47	0.00	0.333	0.338	0.755	-0.337	(g)S	moderately sorted	strongly coarse-skewed
T6 3	0.00	10.65	44.23	36.19	8.58	0.35	0.00	0.00	0.536	0.526	0.767	0.317	S	moderately sorted	strongly fine-skewed
T6 4	0.00	11.94	41.57	35.88	8.58	0.18	1.85	0.00	0.528	0.519	0.825	0.373	S	moderately sorted	strongly fine-skewed

Site	Size class (mm)								Median Size	Graphic Mean Size	Sorting	Skewness	Characterization		
	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay							
	> 2.00	2.00 – 1.00	1.00 – 0.50	0.50 – 0.25	0.250 – 0.125	0.1250 – 0.0625	0.0625 – 0.0039	< 0.0039	(mm)	(mm)					
T6 5	0.66	19.04	39.65	28.35	6.38	0.64	4.91	0.37	0.590	0.568	1.231	5.487	(g)S	poorly sorted	strongly fine-skewed
T6 E	0.19	0.54	12.37	51.14	32.67	1.51	1.58	0.00	0.294	0.296	0.676	-0.061	(g)S	moderately well sorted	near-symmetrical
T7 W	0.00	2.71	39.78	47.97	9.11	0.21	0.22	0.00	0.458	0.453	0.651	0.105	S	moderately well sorted	fine-skewed
T7 M	0.00	6.57	34.67	44.18	13.85	0.32	0.41	0.00	0.443	0.444	0.782	-0.035	S	moderately sorted	near-symmetrical
T7 E	1.60	15.65	39.83	30.88	6.77	0.72	4.25	0.30	0.562	0.549	1.071	2.254	(g)S	poorly sorted	strongly fine-skewed
T8 W	0.00	6.18	45.89	41.09	6.49	0.23	0.12	0.00	0.513	0.508	0.674	0.175	S	moderately well sorted	fine-skewed
T8 0	0.00	3.01	35.70	49.40	11.83	0.06	0.00	0.00	0.436	0.434	0.673	0.024	S	moderately well sorted	near-symmetrical
T8 1	0.00	7.15	39.79	43.46	9.25	0.13	0.22	0.00	0.481	0.480	0.728	-0.020	S	moderately sorted	near-symmetrical
T8 2	0.00	2.17	32.74	48.21	16.47	0.41	0.00	0.00	0.411	0.408	0.716	0.102	S	moderately sorted	fine-skewed
T8 3	2.14	11.38	29.89	37.05	16.59	1.09	1.86	0.00	0.446	0.455	1.014	-0.450	(g)S	poorly sorted	strongly coarse-skewed
T8 4	0.95	1.80	3.45	37.31	48.35	6.42	1.67	0.05	0.232	0.235	0.689	-0.228	(g)S	moderately well sorted	coarse-skewed
T8 5	0.61	14.07	36.63	37.00	11.02	0.40	0.27	0.00	0.511	0.515	0.891	-0.152	(g)S	moderately sorted	coarse-skewed
T8 E	0.82	1.37	4.88	38.19	47.18	5.92	1.59	0.05	0.237	0.240	0.700	-0.269	(g)S	moderately well sorted	coarse-skewed
T9 W	0.00	0.26	30.75	54.91	13.69	0.17	0.22	0.00	0.404	0.401	0.623	0.106	S	moderately well sorted	fine-skewed
T9 0	0.00	0.33	31.51	54.31	13.47	0.17	0.21	0.00	0.407	0.404	0.627	0.116	S	moderately well sorted	fine-skewed
T9 1	0.00	2.69	38.75	47.58	10.45	0.32	0.21	0.00	0.452	0.445	0.669	0.152	S	moderately well sorted	fine-skewed
T9 2	0.00	5.09	41.28	43.67	9.27	0.50	0.19	0.00	0.478	0.472	0.701	0.170	S	moderately well sorted	fine-skewed
T9 3	0.00	6.73	45.75	41.02	6.01	0.37	0.12	0.00	0.516	0.512	0.675	0.132	S	moderately well sorted	fine-skewed
T9 4	0.00	0.85	18.69	50.28	28.63	1.55	0.00	0.00	0.324	0.326	0.708	-0.095	S	moderately well sorted	near-symmetrical
T9 5	0.00	0.00	16.85	53.37	28.28	1.00	0.50	0.00	0.320	0.321	0.659	-0.007	S	moderately well sorted	near-symmetrical
T9 E	0.00	0.00	2.57	38.01	51.09	6.74	1.54	0.05	0.225	0.225	0.625	0.021	S	moderately well sorted	near-symmetrical
TC W	0.00	7.67	45.37	40.26	6.20	0.36	0.14	0.00	0.520	0.516	0.691	0.130	S	moderately well sorted	fine-skewed
TC M	1.12	17.92	48.52	28.90	2.84	0.51	0.19	0.00	0.635	0.637	0.751	-0.007	(g)S	moderately sorted	near-symmetrical
TC E	0.90	3.19	5.57	27.83	46.94	10.40	4.50	0.67	0.211	0.217	1.108	1.266	(g)S	poorly sorted	strongly fine-skewed
T10 W	0.00	0.34	30.76	54.80	12.60	0.03	1.47	0.00	0.404	0.402	0.629	0.132	S	moderately well sorted	fine-skewed
T10 0	0.00	2.54	38.46	48.71	9.12	0.22	0.95	0.00	0.450	0.445	0.654	0.100	S	moderately well sorted	fine-skewed
T10 1	0.00	1.70	33.60	51.55	13.15	0.00	0.00	0.00	0.419	0.418	0.657	0.037	S	moderately well sorted	near-symmetrical
T10 2	0.00	0.67	29.56	52.51	17.09	0.17	0.00	0.00	0.393	0.391	0.665	0.070	S	moderately well sorted	near-symmetrical
T10 3	0.00	0.26	22.60	52.41	23.98	0.75	0.00	0.00	0.352	0.351	0.683	0.062	S	moderately well sorted	near-symmetrical
T10 4	0.55	0.90	7.21	41.94	42.45	4.94	1.96	0.05	0.252	0.253	0.716	-0.100	(g)S	moderately sorted	near-symmetrical
T10 5	0.00	3.58	47.63	43.16	4.54	0.94	0.15	0.00	0.507	0.503	0.615	0.165	S	moderately well sorted	fine-skewed
T10 E	1.20	20.52	46.35	26.79	2.49	0.90	1.70	0.05	0.647	0.651	0.808	0.085	(g)S	moderately sorted	near-symmetrical

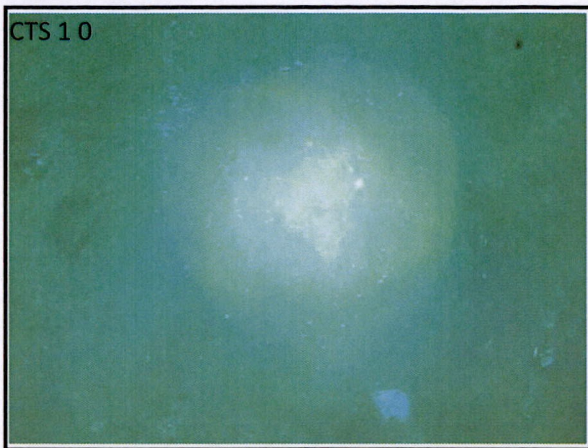
Appendix 3 Drop Camera Images

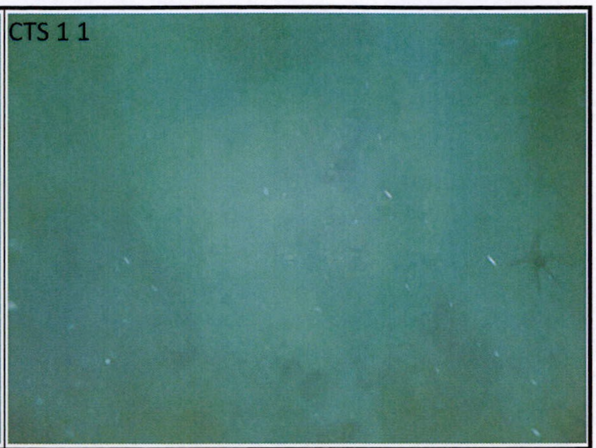
Table 18 Seabed photography summary descriptions, 2003.

Transect	Comments
Video Sled Transect 1	The offshore 2/3rds of the transect is comprised of large shore-parallel symmetrical mega ripples consisting of coarse sand with a lag of shell material and worm-cases in the troughs. 2/3rds of the way along the transect, the ripples become less defined and are visibly of a finer grade material, the shell and worm-case lag is of lower density and the rare horse mussel can be seen. Moving inshore through the last 1/3rd of the transect, the size of the bedforms decreases, with occasional horse mussels. Other visible signs of life along the transect include worm and crustacea holes, hermit crabs and a small bottom-dwelling fish.
Drop-Camera Transect 1 (Sites 102-96)	Characteristics are very similar to those described for the sled transect above, which covered the same area, with the trend towards finer sediments and less defined mega-ripples moving shoreward.
Video Sled Transect 2	Similar characteristics were observed along the second sled transect as those reported above for the first. However, the sand remains coarse and with mega-ripples until near the inshore end of the transect (where it becomes finer and the size of the bedforms decreases) and lower numbers of horse mussels are present.
Drop-Camera Transect 2 (Sites 66-73)	Characteristics are very similar to those described for the sled 1 transect above, with the trend towards finer sediments and less defined mega-ripples moving shoreward (this occurs at site 69). However, in the last drop-camera site (73) there is a reversal to coarse grain ripples with shell and worm-case lag in the troughs and the boundary between the 'lens' or 'finger' of fine sand overlaying the coarse sand is clearly visible.
Drop-Camera Transect 3 (Sites 83-74)	Characteristics are very similar to those described for the sled 1 transect above, with the trend towards finer sediments and less defined ripples moving shoreward (this occurs at site 79). Ripples get progressively smaller moving shorewards, until at the last site (74) the seabed is featureless, except for clumps of worm-cases.
Drop-Camera Transect 4 (Sites 95-84)	But for some rippling of the seabed near the shoreward end of the transect (site 86), this transect consists entirely of featureless fine sand. Of note is the sparse population horse mussels in the central region of the transect (sites 94-92), which although at higher densities than in any other transects, are far less dense than those identified by previous studies in shallower depths < 25 m) (e.g. Healy *et al.*, 1996). Bioturbation of the seabed is clearly visible on the featureless fine sand in the form of worm and crustacean holes and the tracks of gastropods and hermit crabs.

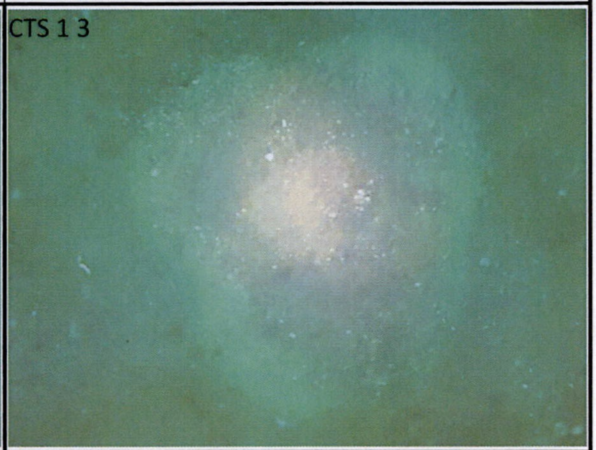
Table 19 Seabed photography summary descriptions, 2006.

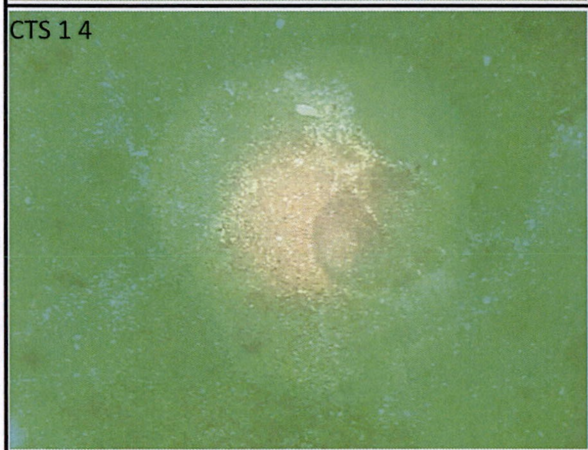
Transect	Comments
Transect 1 P002-P008	The transect videos are comprised of large shore-parallel symmetrical mega-ripples consisting of coarse sand with a lag of shell material and parchment worm-cases (*Chaetopterus* spp.) in the troughs. Bioturbation of the seabed is clearly visible. Detrital material and shell lag appear prominent closer to shore. Scallops are present in all video clips along the transect, except for P004 and 005.
Transect 2 P0I6-P009	Similar characteristics were observed along the second transect as those reported for the first transect. Moving from offshore to inshore areas the sand becomes finer, the size of the bedforms decrease and there is an increase in shell lag and detritus. Scallops are present in all video clips along the transect, except for PO 14 and 015.
Transect 3 P017-P023	This transect appears more uniform in the distribution of shell lag, bioturbation and fine sand than the above transects. Mega-ripples are less defined than the first two transects. Scallops are present in all video clips along the transect.
Transect 4 P031-P024	Fish (blue cod - *Parapercis colias*) appear attracted to the drop camera at drop P031. Shell lag and irregular mega-ripples are present throughout this transect. This transect is particularly uniform in features. Scallops are present in all video clips along the transect, except for P031.
Transect 5 P033-P040	Regular mega-ripples occur on the offshore part of transect. The ripples steepen in the middle of transect and are less organized shoreward. Finer sands and bioturbation are also more prominent shoreward. Shell lag, and scallops are prominent throughout. Scallops are present in all video clips along the transect, except for P039 and 040.
Transect 6 P048-P041	Shell lag, fine sands and uneven ripples on the offshore part of transect continue through to the inside with the ripples becoming slightly more regular shoreward. Scallops are only present in the P047 and 044 video clips.
Transect 7 P049-P056	Shell lag, fine sands and uneven ripples on the offshore part of transect continue through to the inside with the ripples becoming slightly more regular shoreward. Scallops are present in 50% of the video clips along the transect (P051, 052, 053 and 055).
Transect 8 P064-P057	Irregular sand ripples throughout this transect with shell lag and bioturbation consistently along transect. Scallops are present in 3 video clips along the transect (P060, 058 and 057).

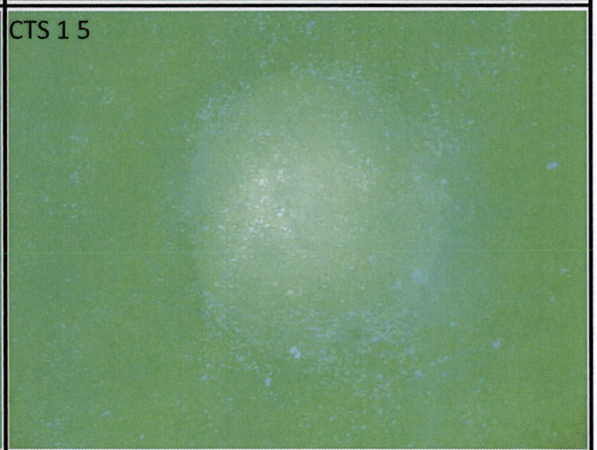

CTS 1 0

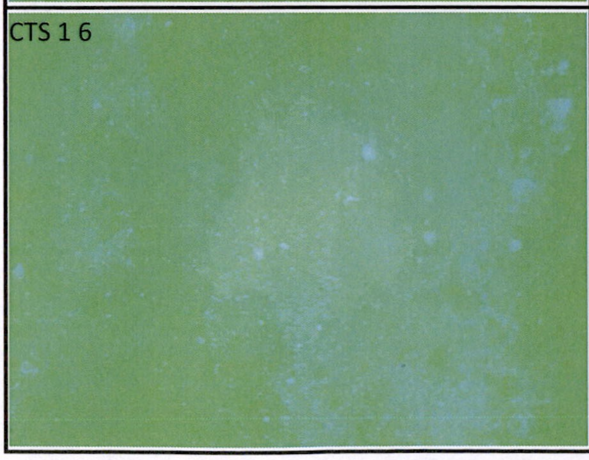

CTS 1 1

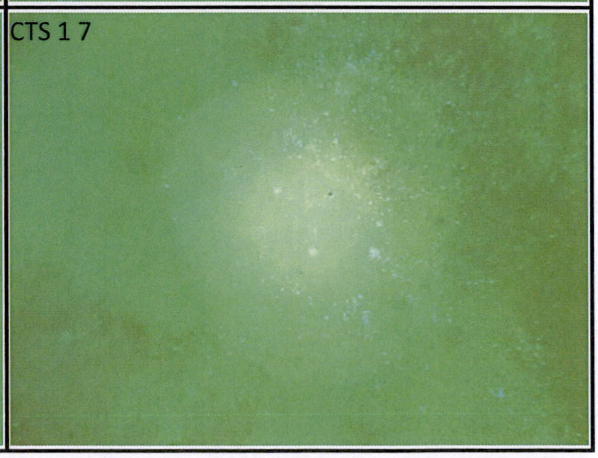

CTS 1 2


CTS 1 3


CTS 1 4


CTS 1 5


CTS 1 6


CTS 1 7

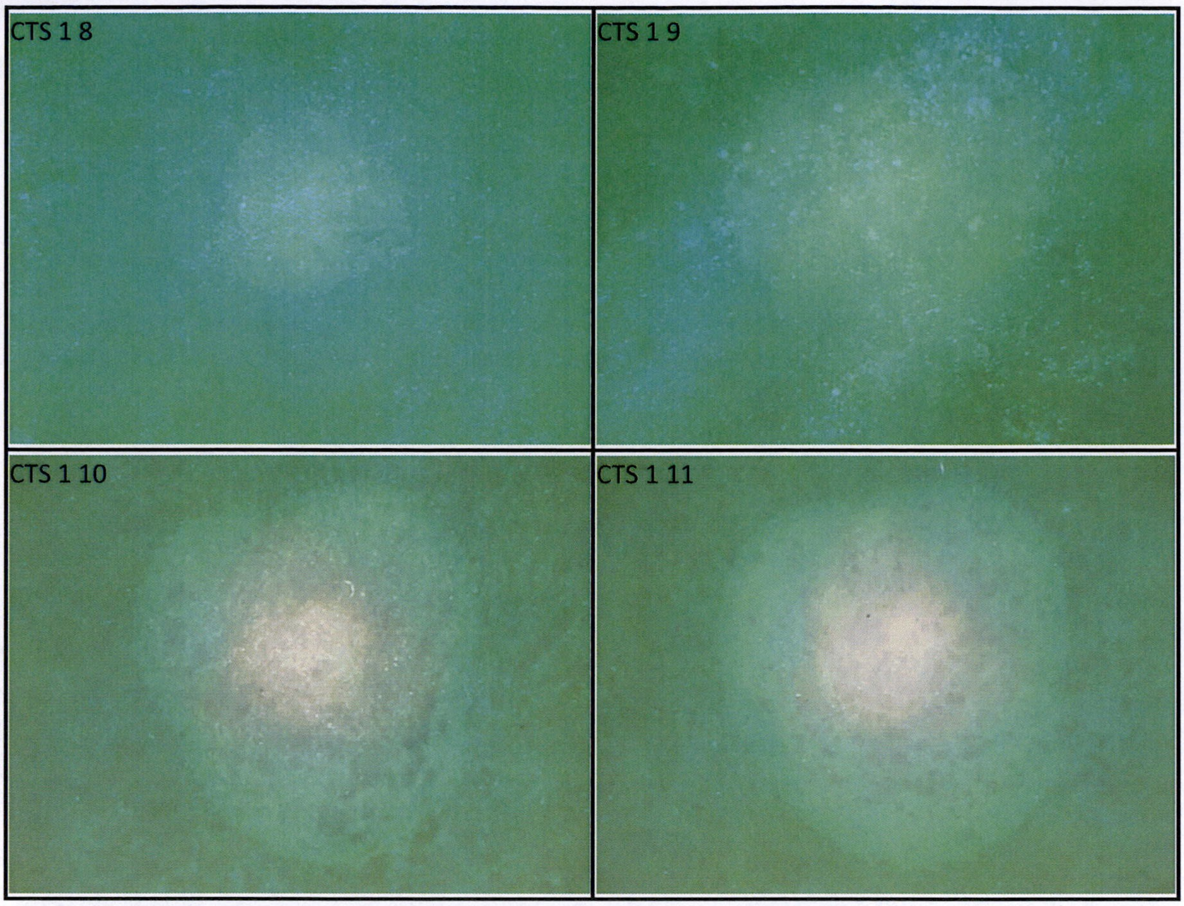
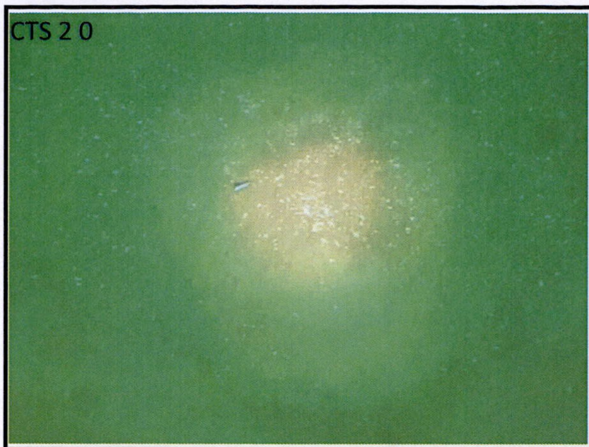
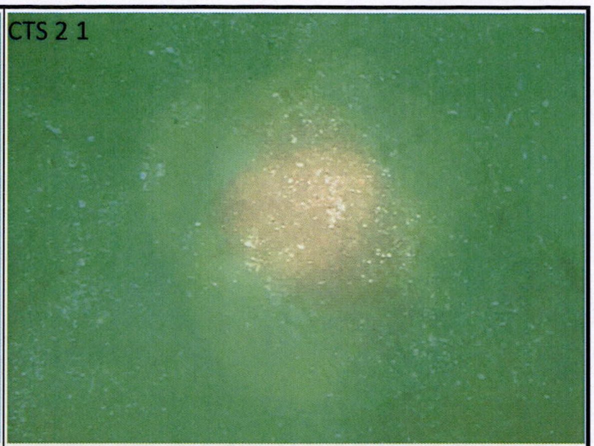
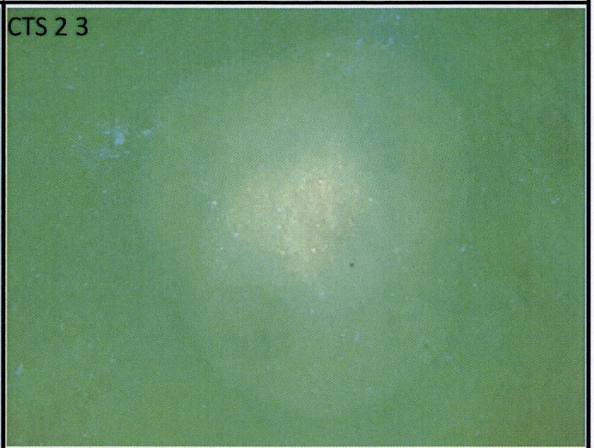


Figure 7.1 Drop Camera images from Control Site Transect 1, July 2011

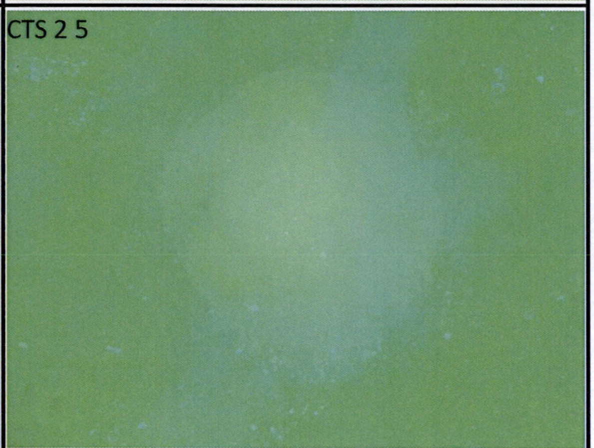

CTS 2 0

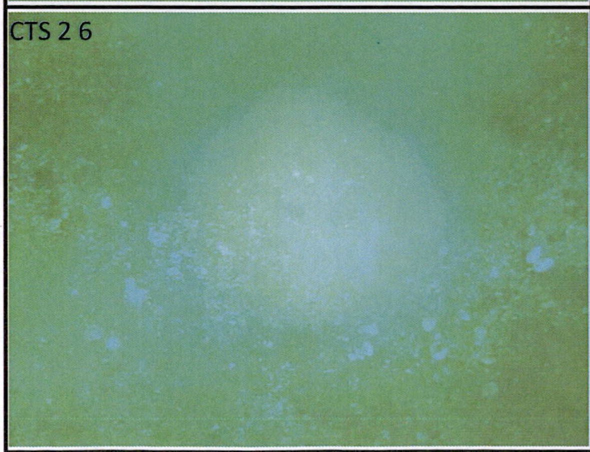

CTS 2 1

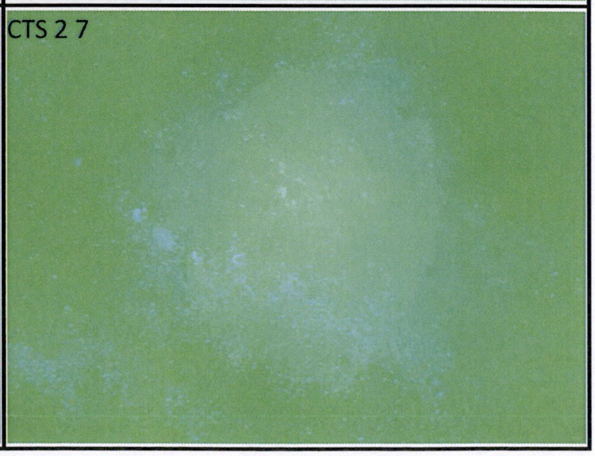

CTS 2 2


CTS 2 3


CTS 2 4


CTS 2 5


CTS 2 6


CTS 2 7

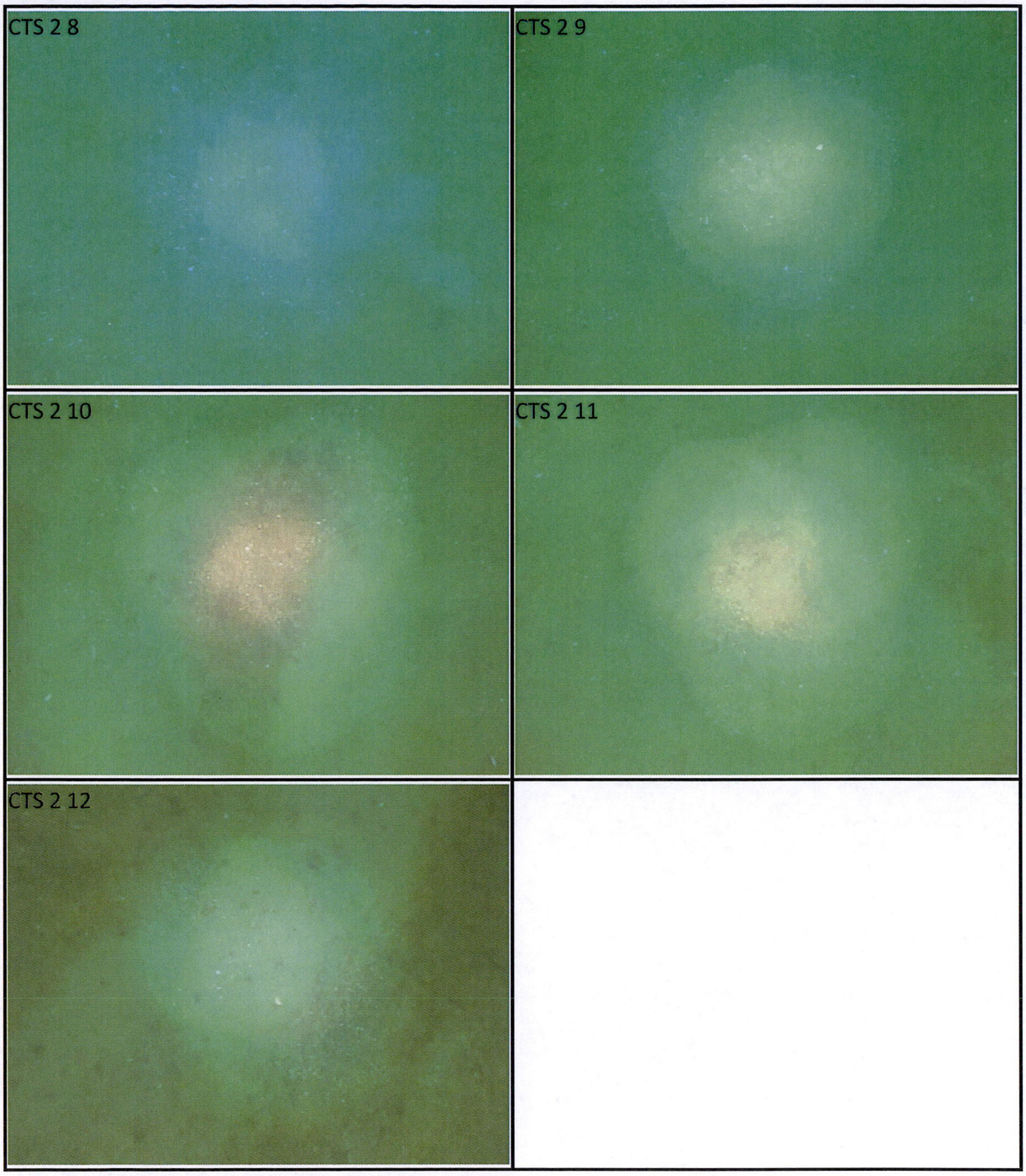


Figure 7.2 Drop Camera images from Control Site Transect 2, July 2011

Table 20 Seabed photography summary descriptions, 2011.

Site	Off	>30	<30	In	Comments	
CT1.00			x		Sandy with muddy areas, shell lag, uneven ripples	Bioturbation, worm whole
CT1.01			x		Sandy mega ripples	Bioturbation, *Astropecten* and *Struthiolaria*
CT1.02			x		Sandy with muddy areas, shell lag, uneven ripples	Bioturbation
CT1.03			x		Sandy shell lag, mega ripples	Bioturbation
CT1.04			x		Sandy shell lag, mega ripples	Bioturbation
CT1.05			x		Sandy shell lag, mega ripples	Bioturbation
CT1.06			x		Sandy shell lag, mega ripples	Bioturbation
CT1.07		x			Sandy with muddy areas, shell lag, mega ripples	Bioturbation, *Maoricolpus*
CT1.08		x			Sandy mega ripples	
CT1.09		x			Sandy shell lag, mega ripples	
CT1.10		x			Sandy, no ripples	
CT1.11		x			Sandy, no ripples	
CT2.00			x		Sandy, no ripples	*Astropecten*
CT2.01			x		Sandy with muddy areas	*Astropecten*
CT2.02			x		Sandy with muddy areas, uneven ripples	
CT2.03			x		Sandy with muddy areas, uneven ripples	*Luidia*
CT2.04			x		Sandy shell lag, ripples	
CT2.05			x		Sandy with muddy areas, shell lag, ripples	
CT2.06		x			Sandy with muddy areas, shell lag, ripples	
CT2.07		x			Sandy with muddy areas, shell lag, mega ripples	
CT2.08		x			Sandy with muddy areas, ripples	
CT2.09		x			Sandy	
CT2.10		x			Sandy with muddy areas, ripples	
CT2.11		x			Sandy, uneven ripples	
CT2.12		x			Sandy, uneven ripples	

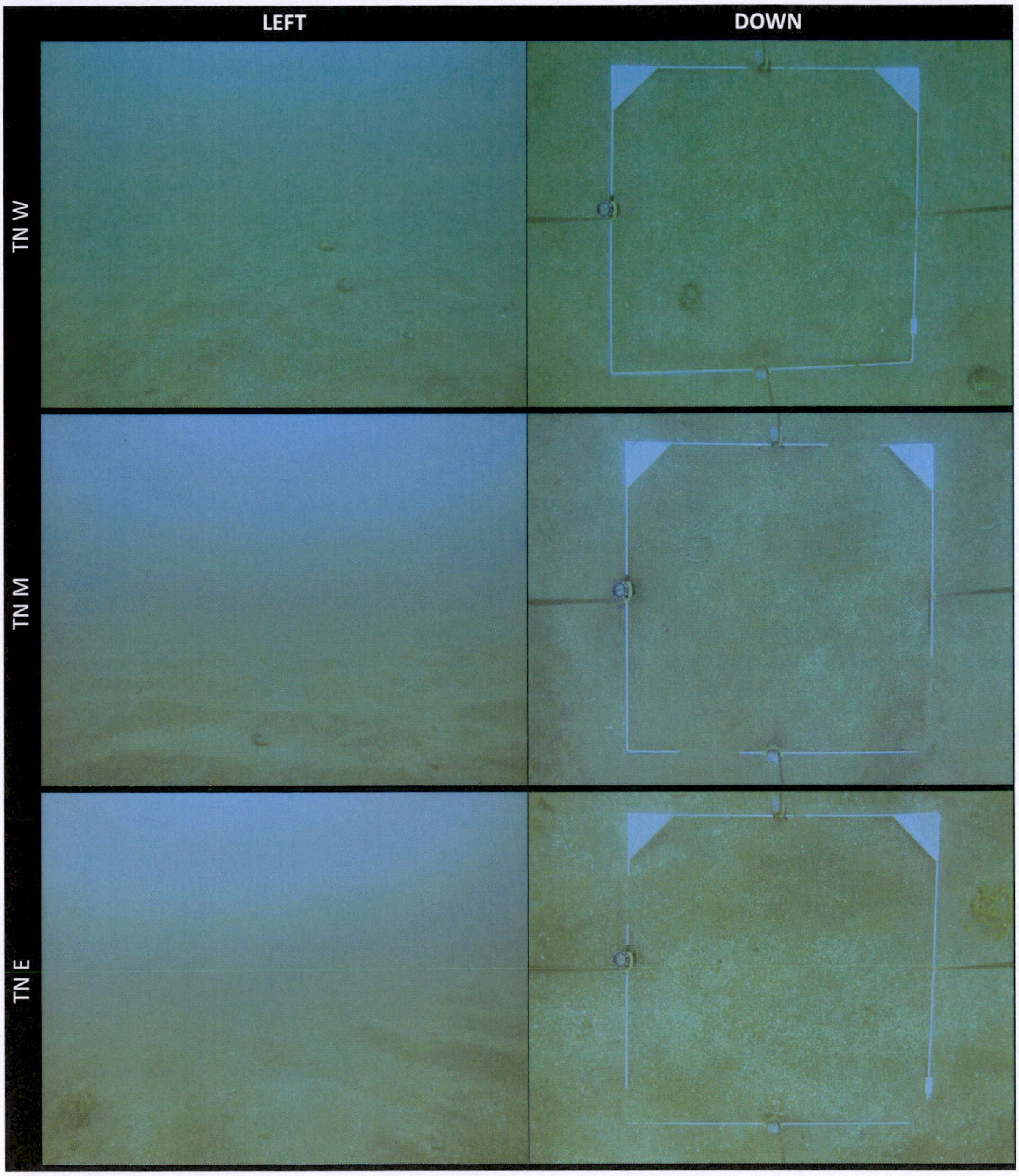
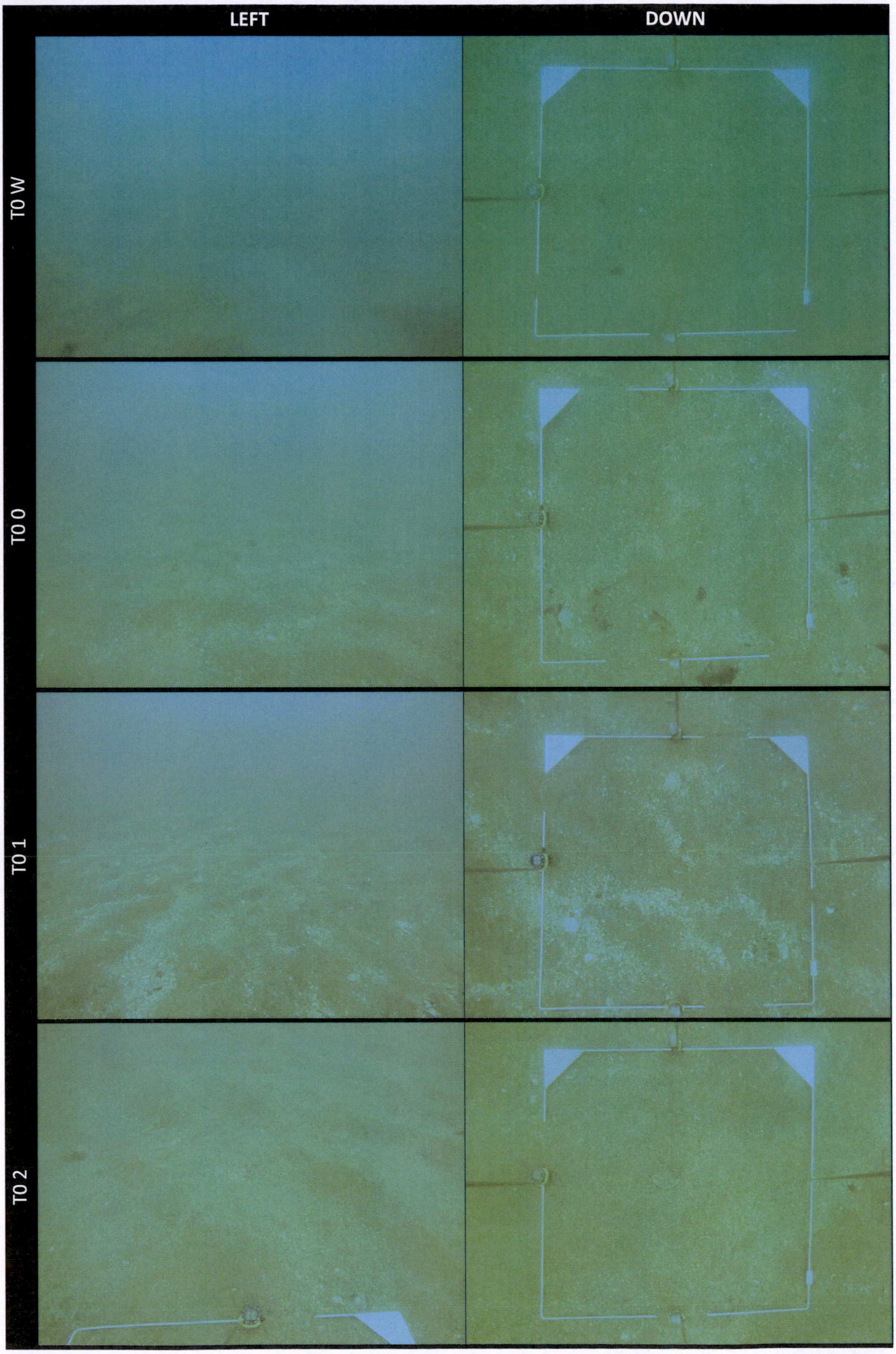


Figure 7.3 Drop Camera images from Transect TN, 18 December 2017


LEFT
DOWN
TO W
TO 0
TO 1
TO 2

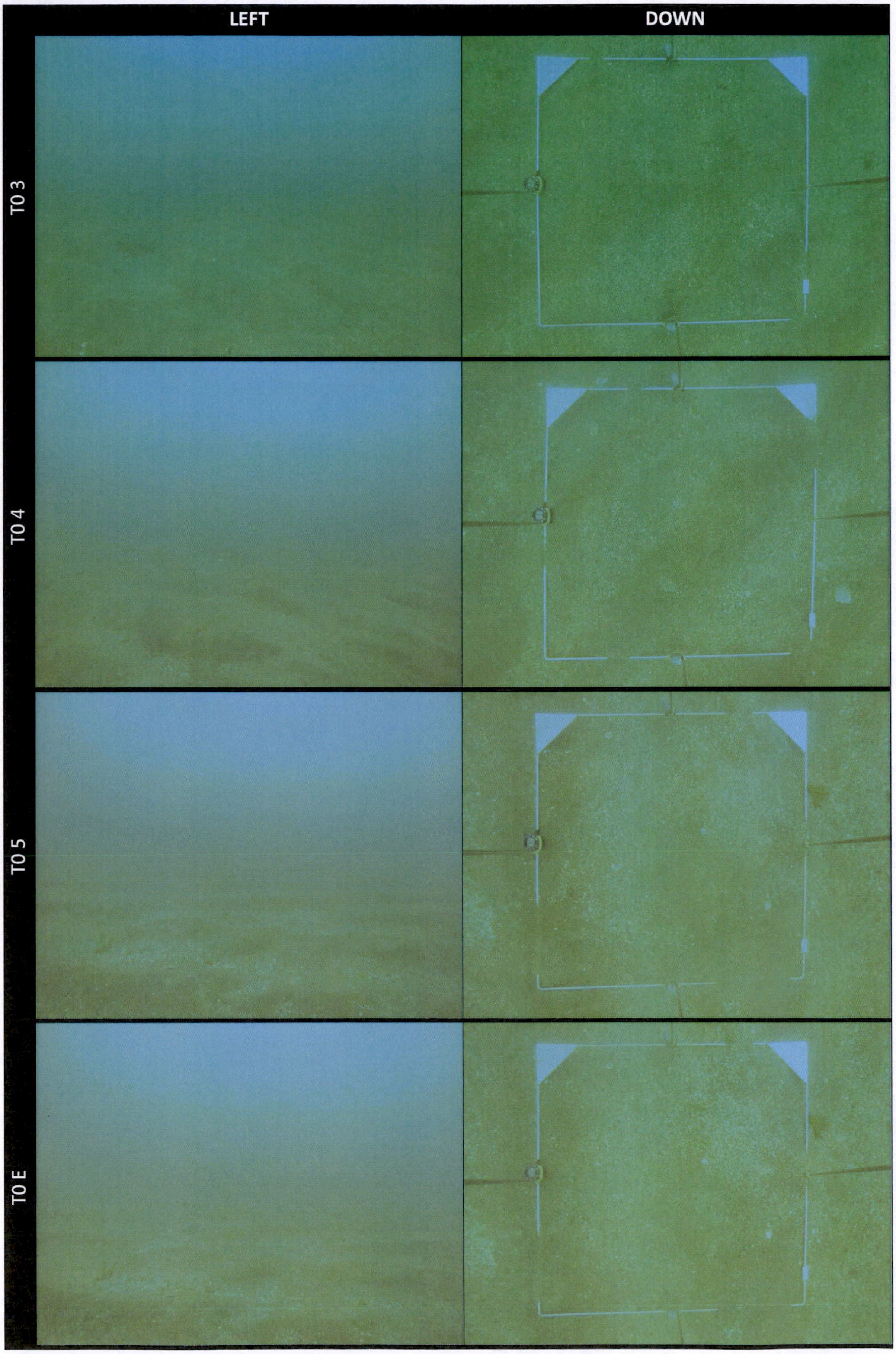


Figure 7.4 Drop Camera images from Transect T0, 18 December 2017

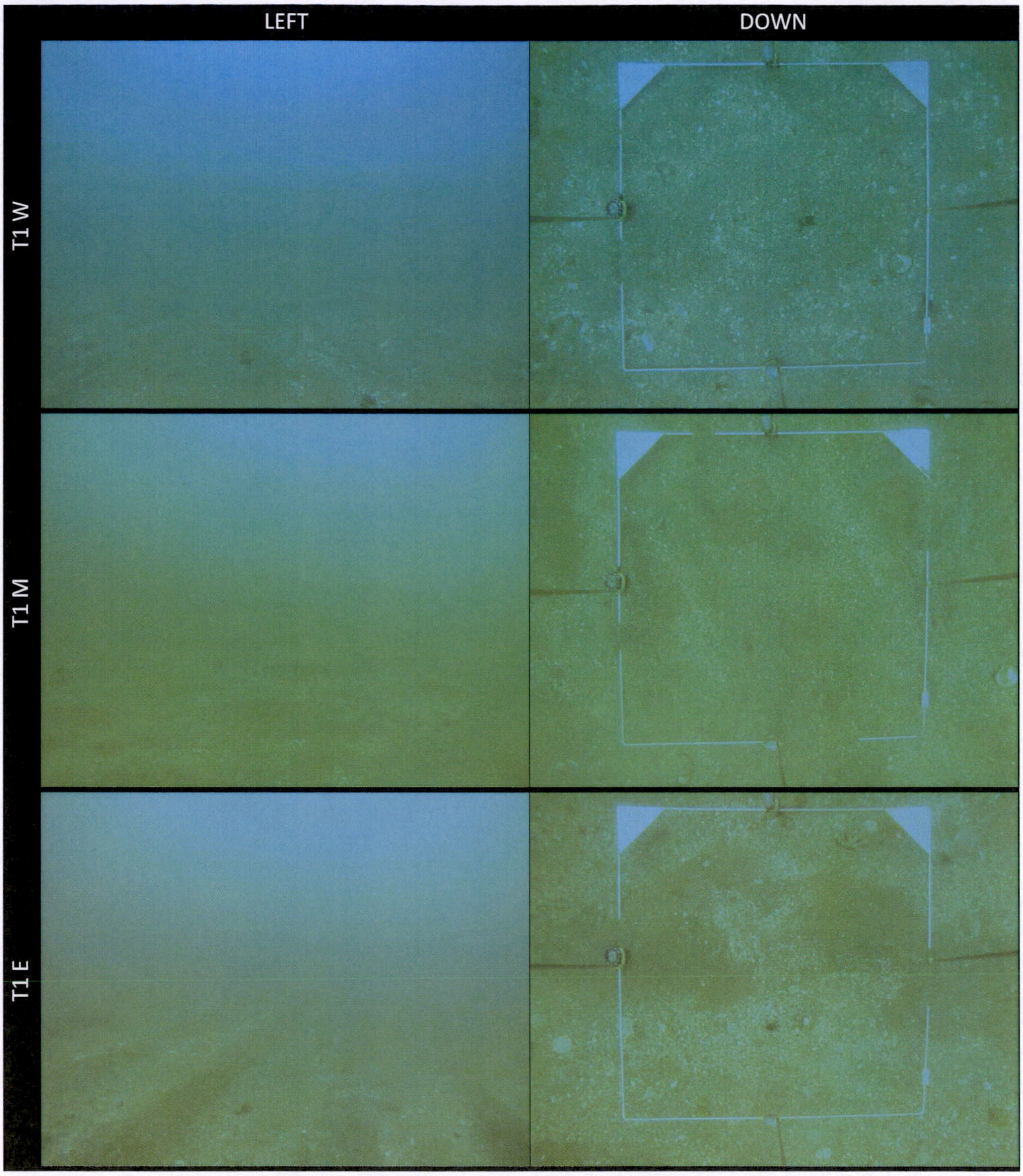
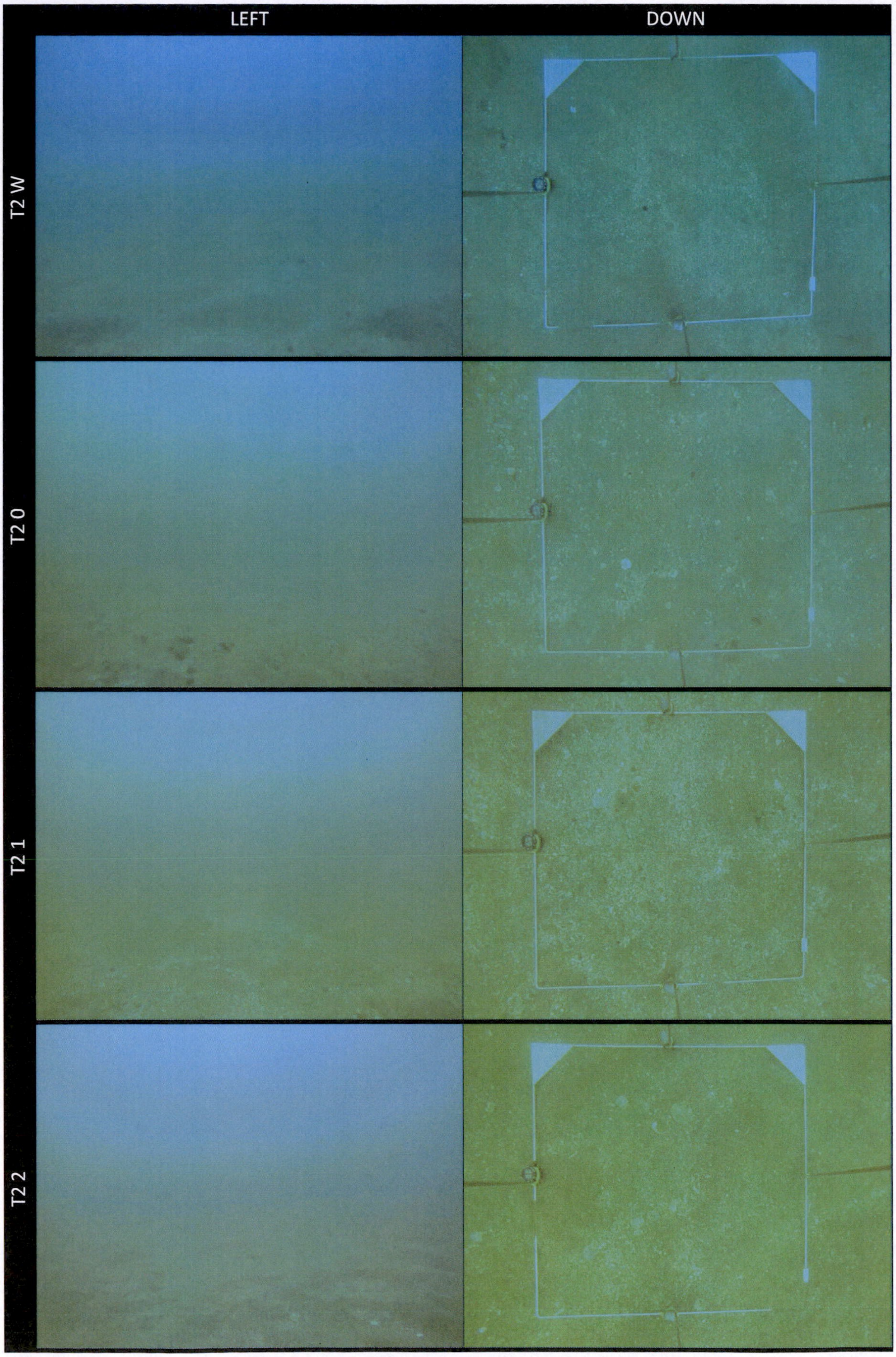


Figure 7.5 Drop Camera images from Transect T1, 18 December 2017


LEFT
DOWN
T2 W
T2 0
T2 1
T2 2

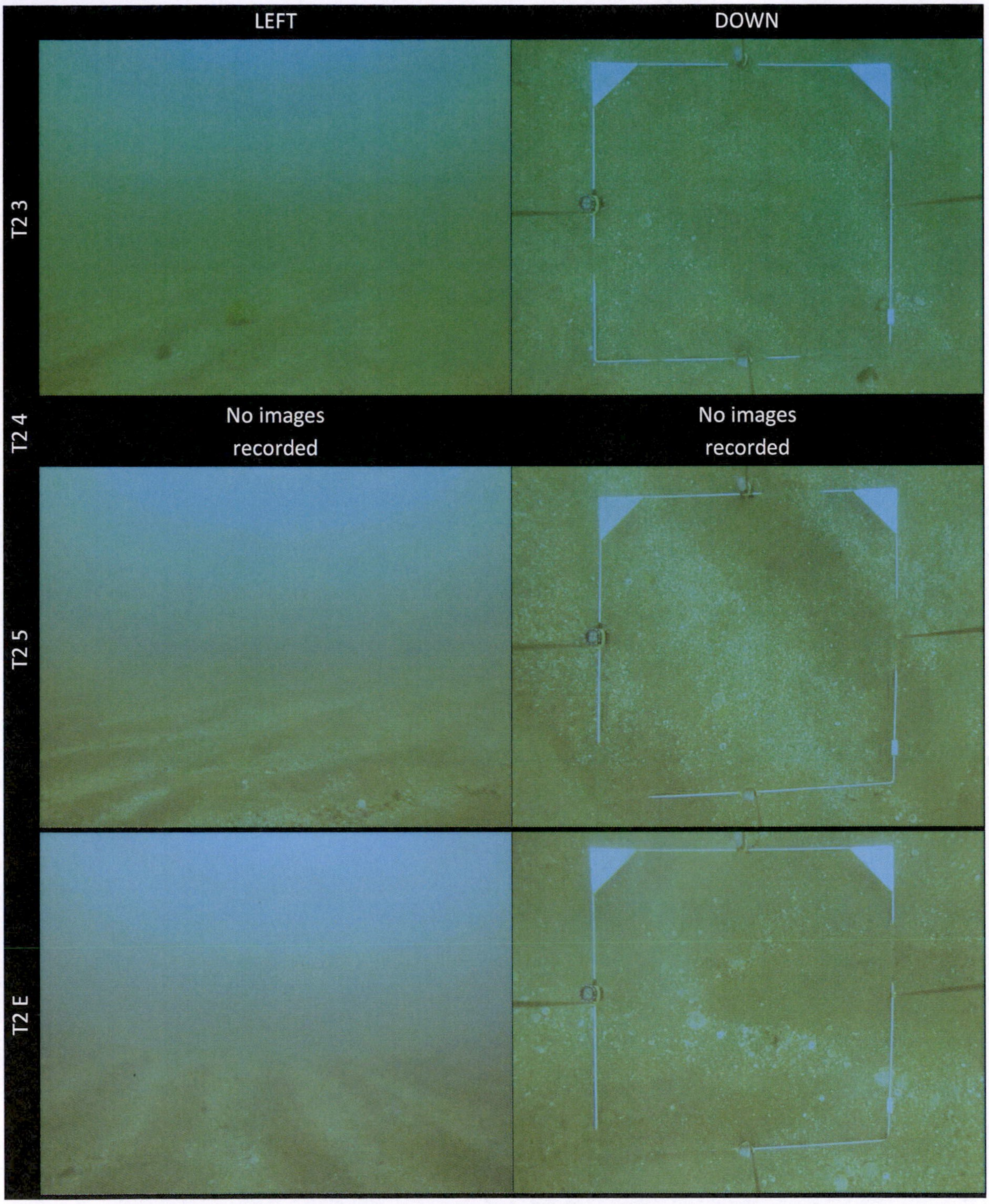


Figure 7.6 Drop Camera images from Transect T2, 18 December 2017

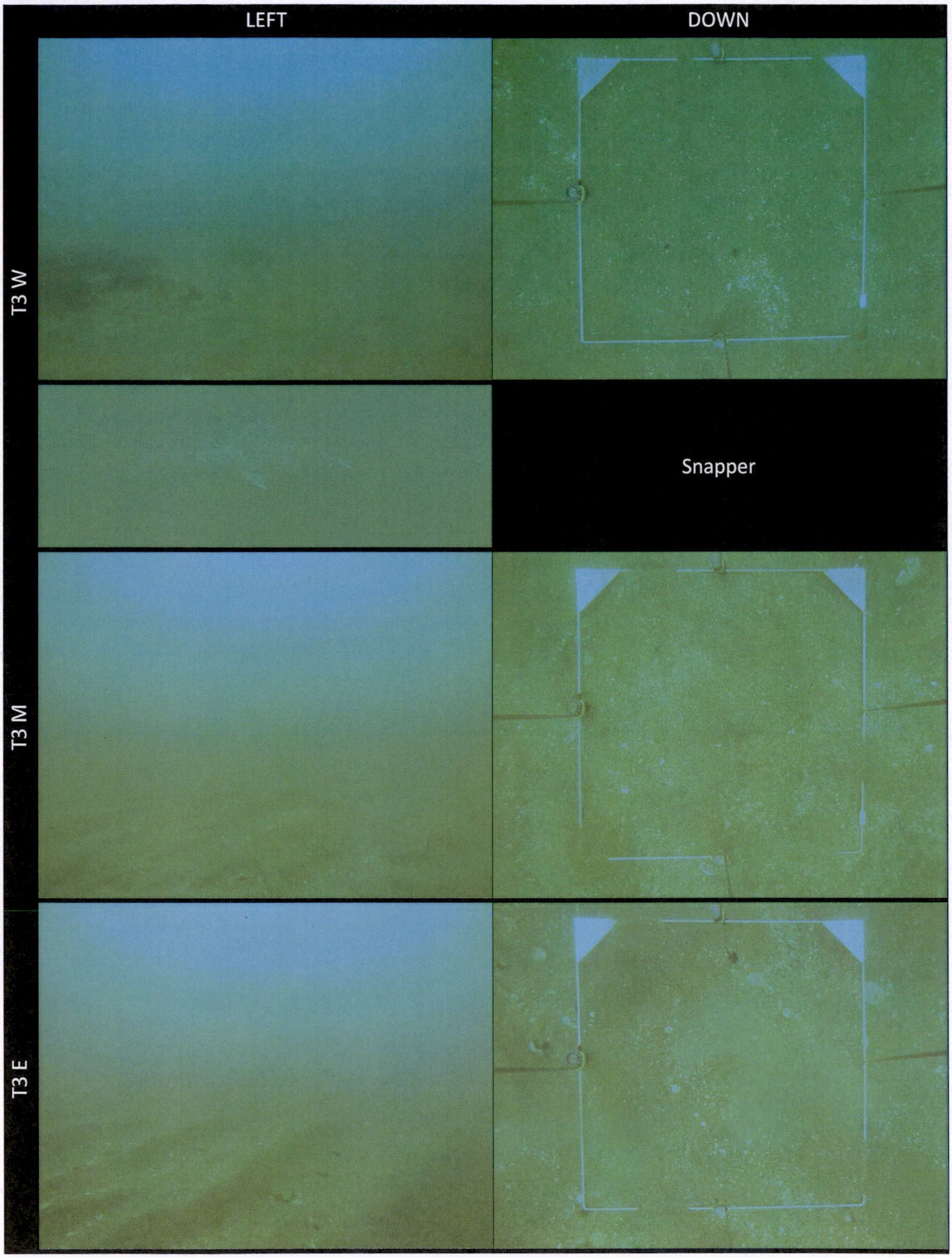
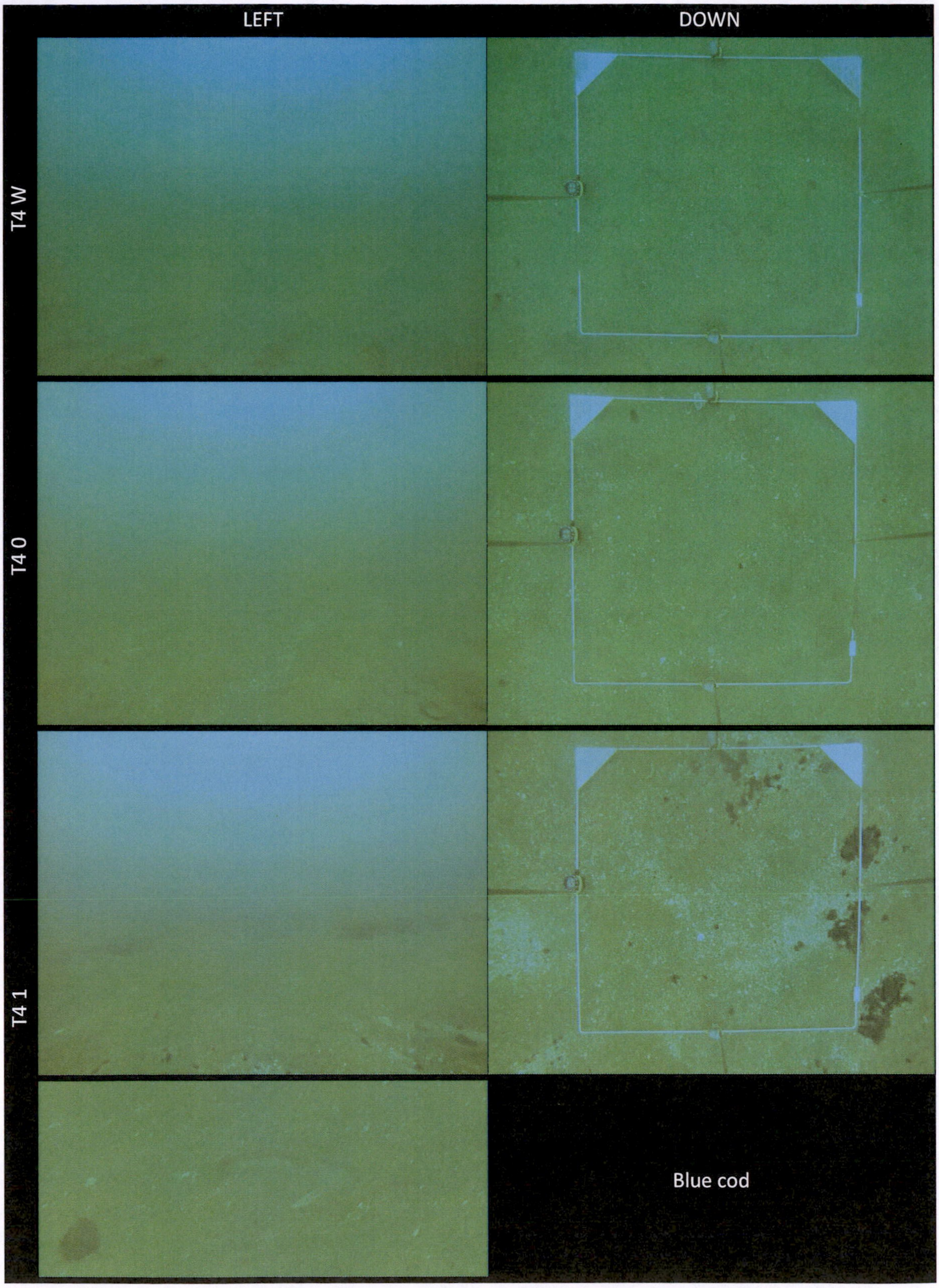
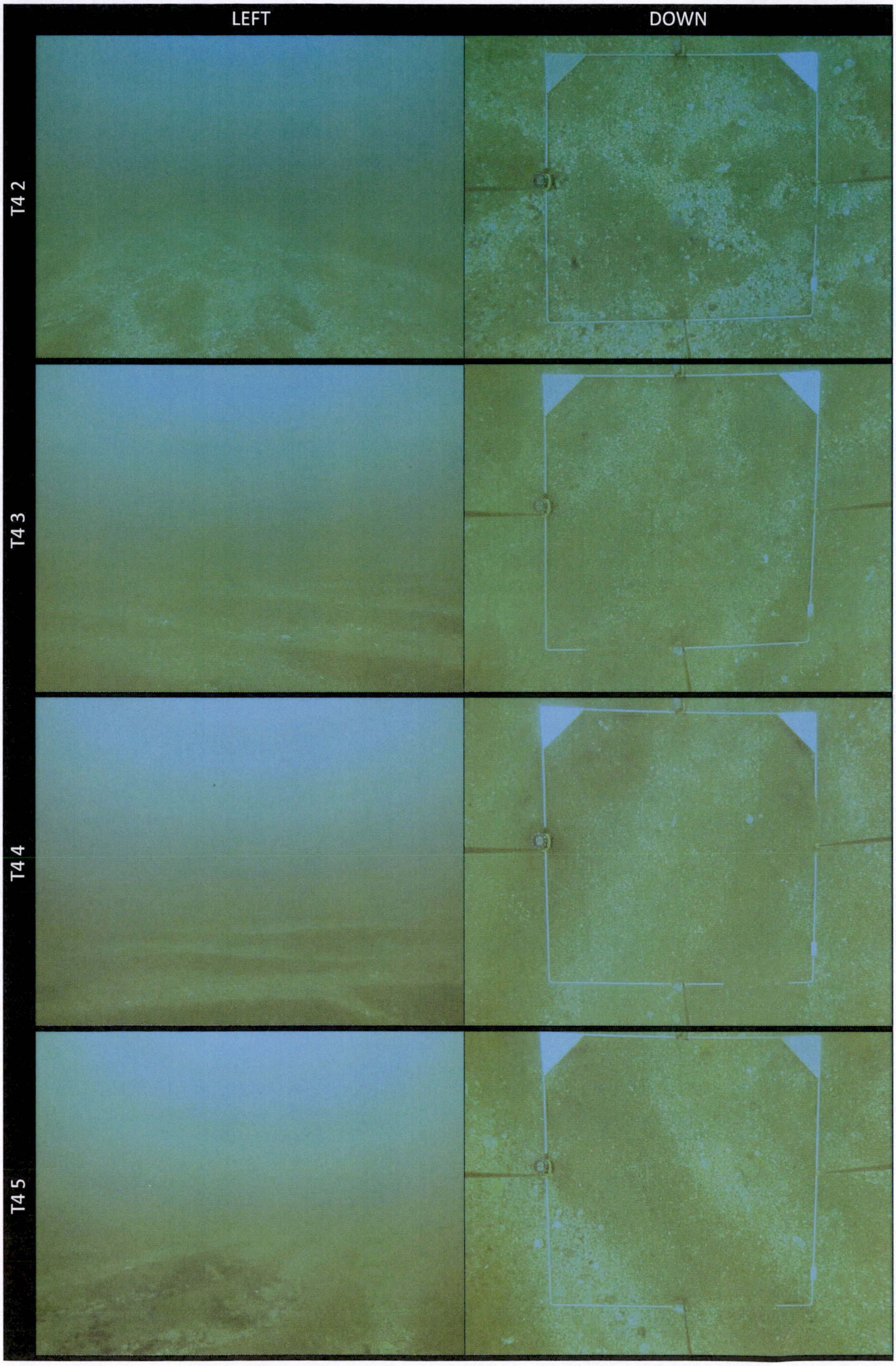


Figure 7.7 Drop Camera images from Transect T3, 18 December 2017


LEFT
DOWN
T4 W
T4 0
T4 1
Blue cod


LEFT
DOWN
T4 2
T4 3
T4 4
T4 5

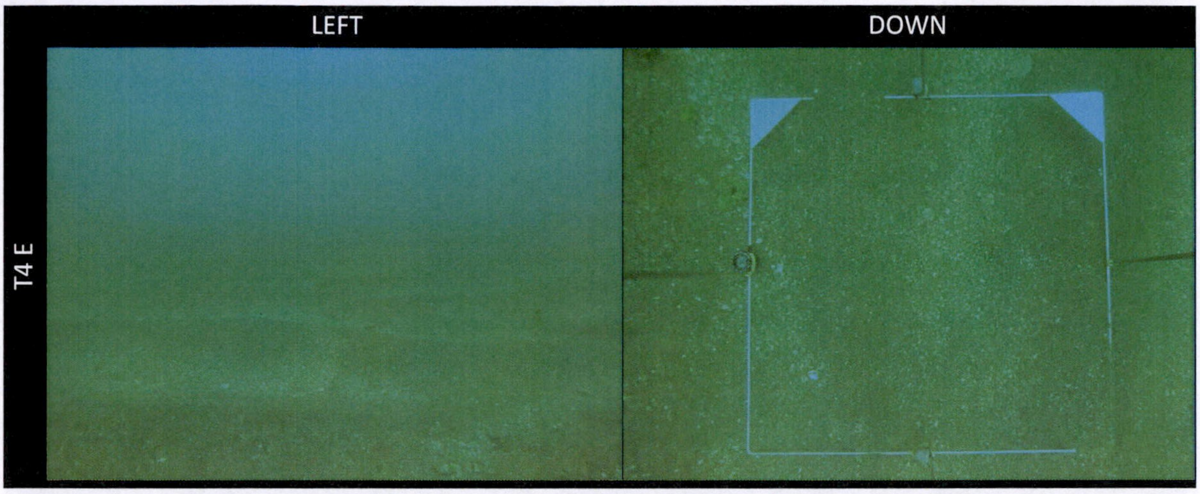
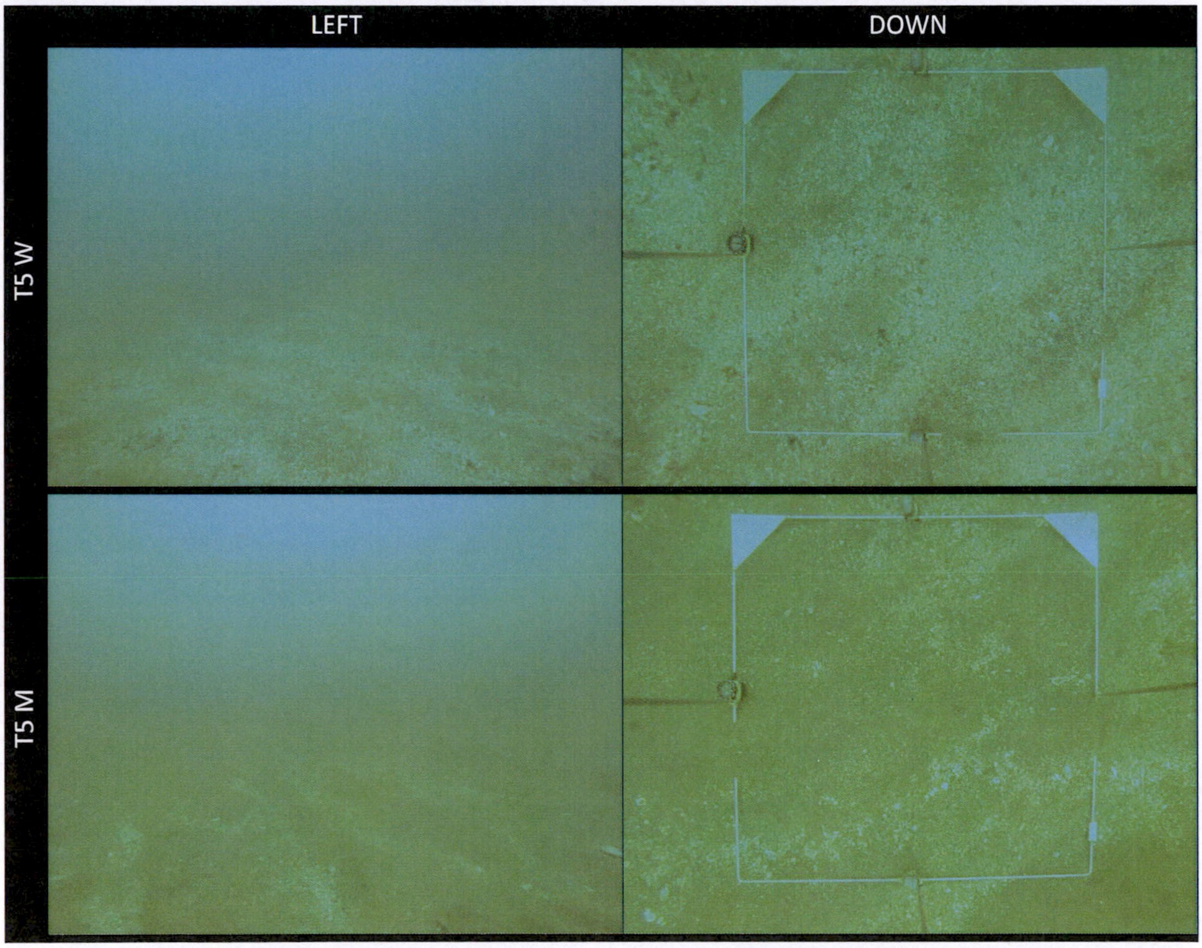


Figure 7.8 Drop Camera images from Transect T4, 18 December 2017



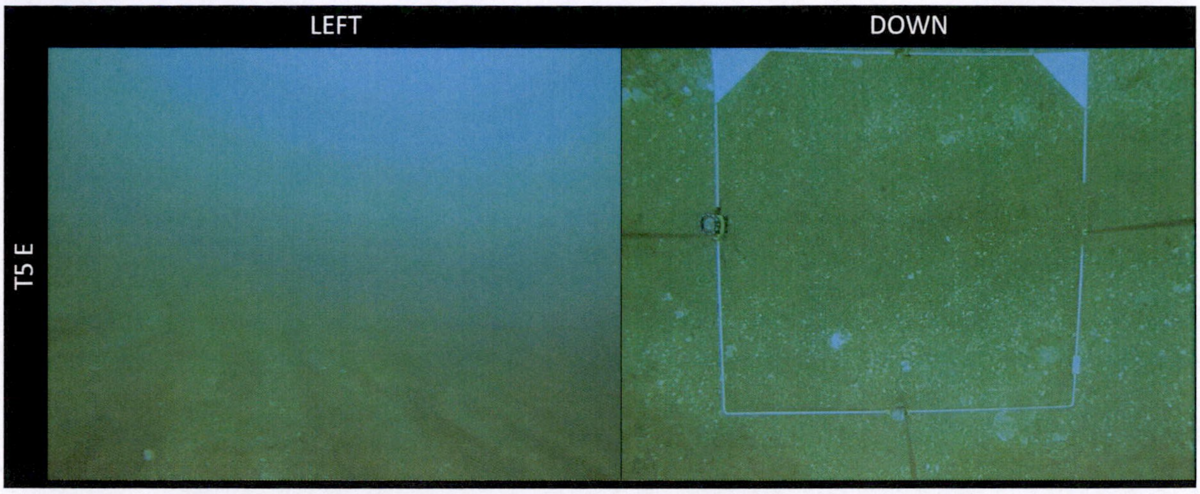
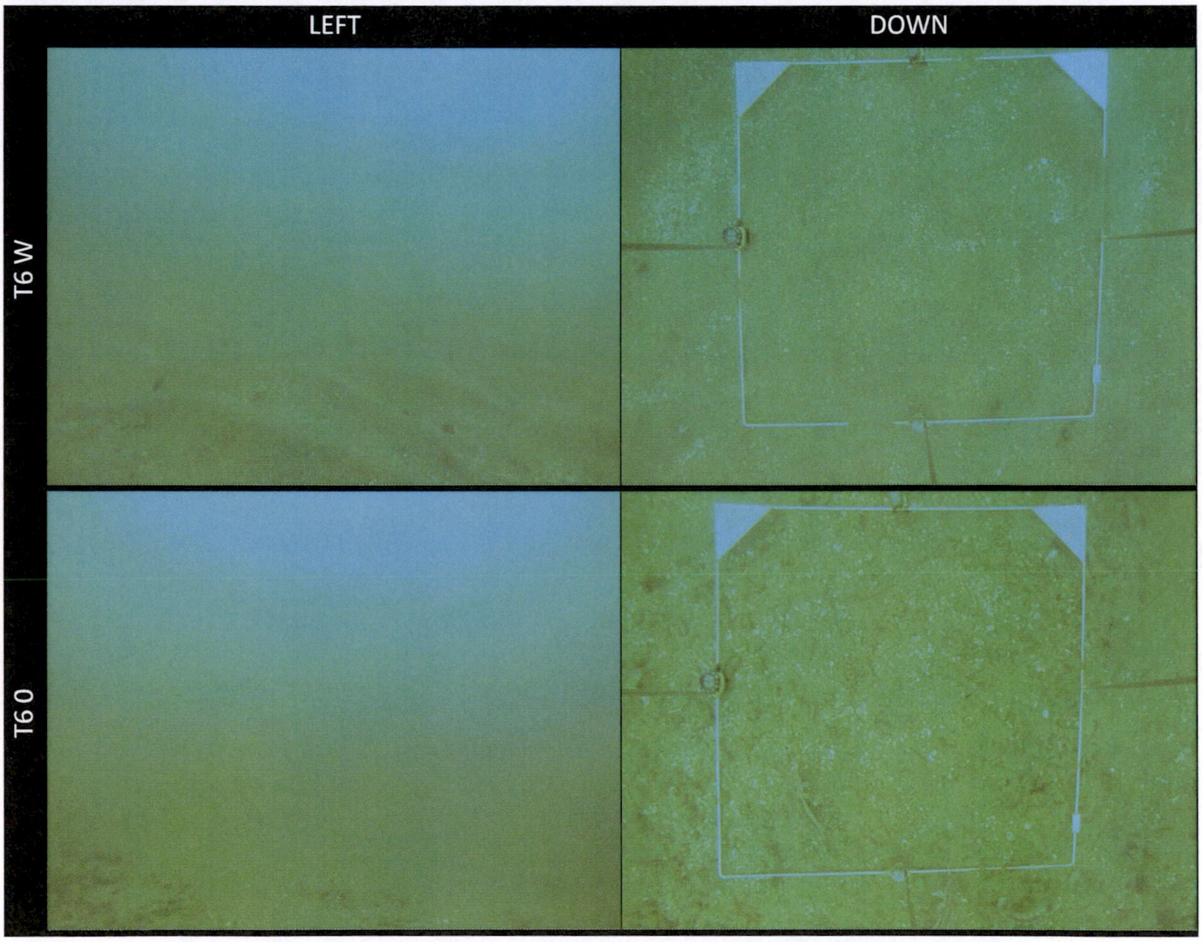
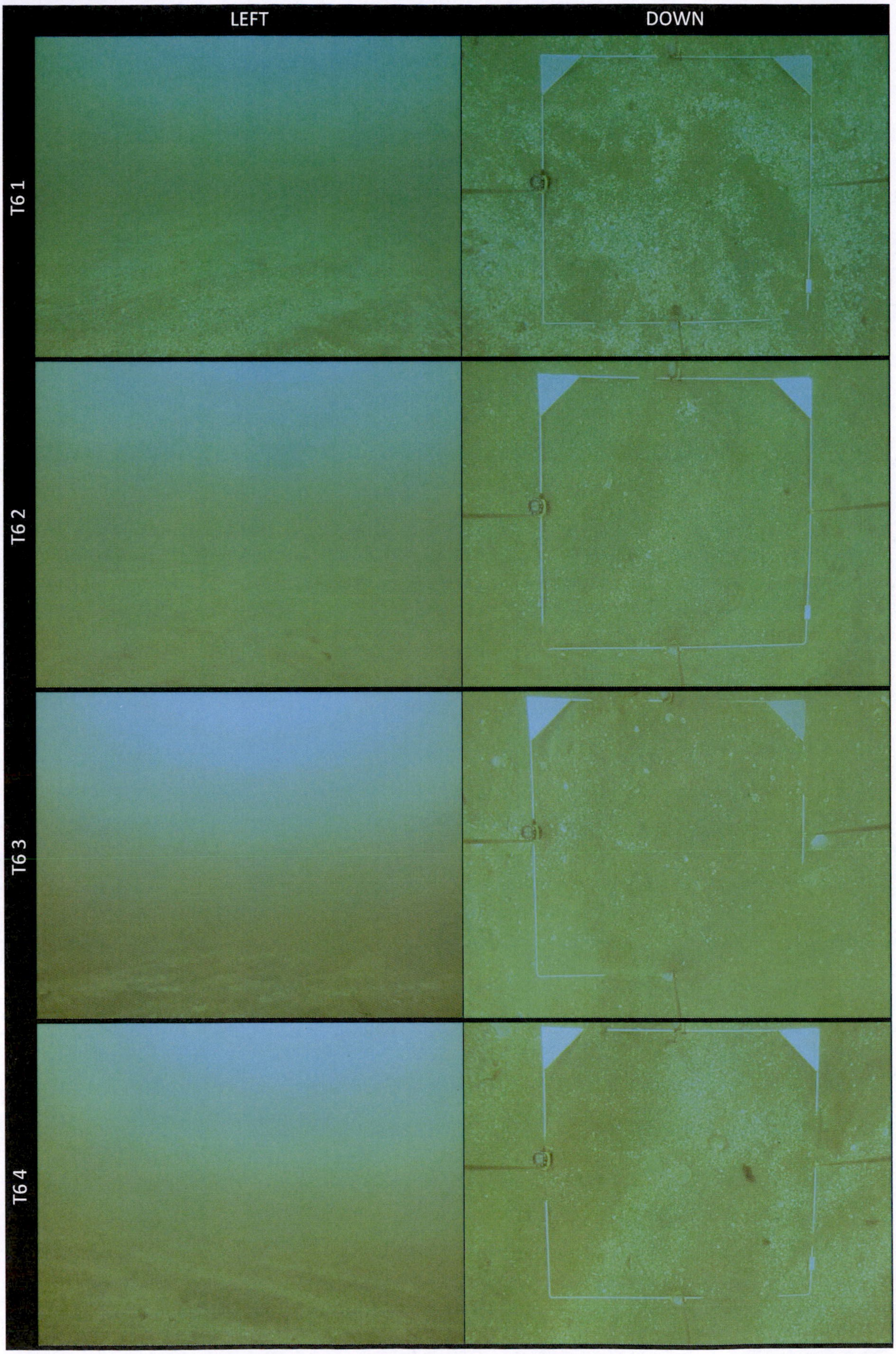


Figure 7.9 Drop Camera images from Transect T5, 18 December 2017




LEFT
DOWN
T6 1
T6 2
T6 3
T6 4

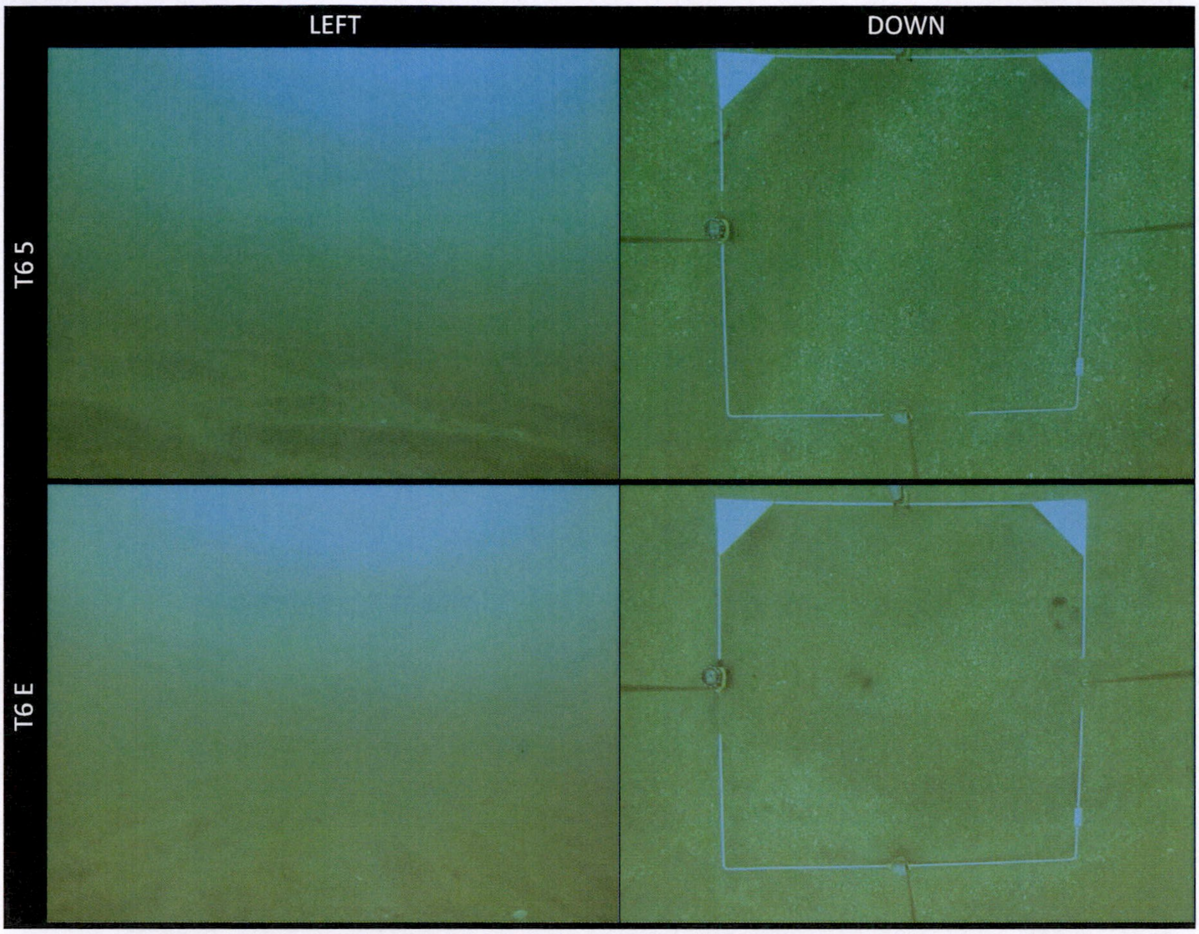
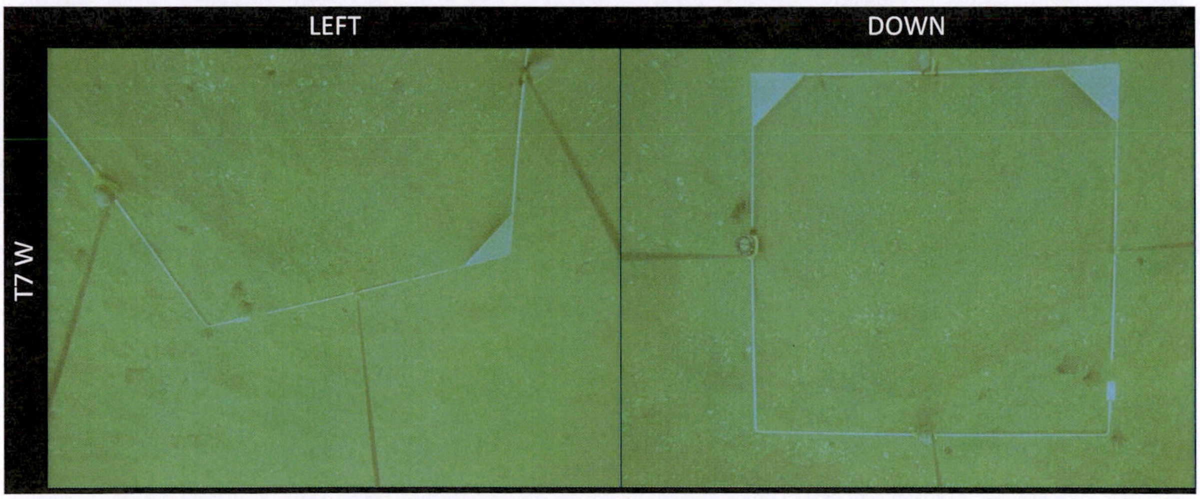


Figure 7.10 Drop Camera images from Transect T6, 18 December 2017



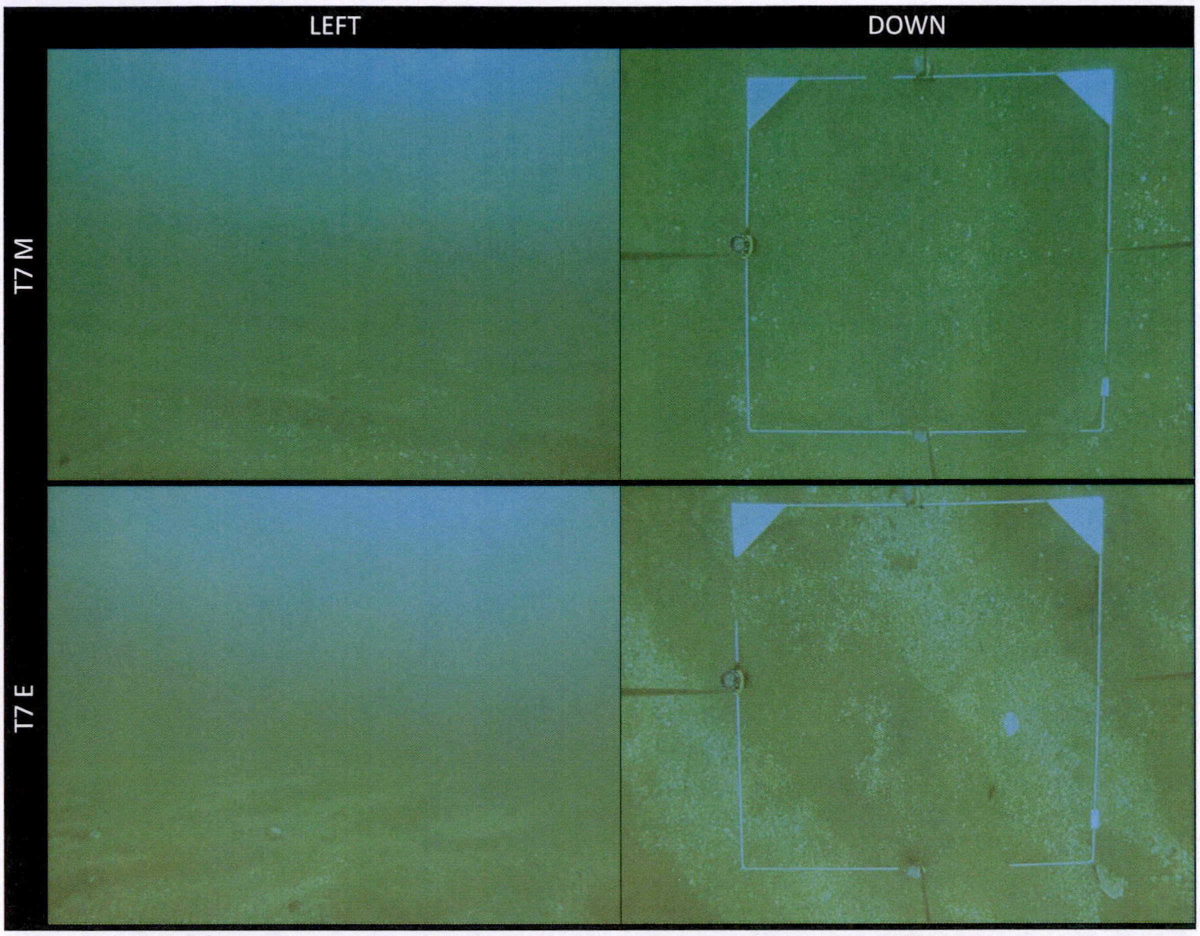
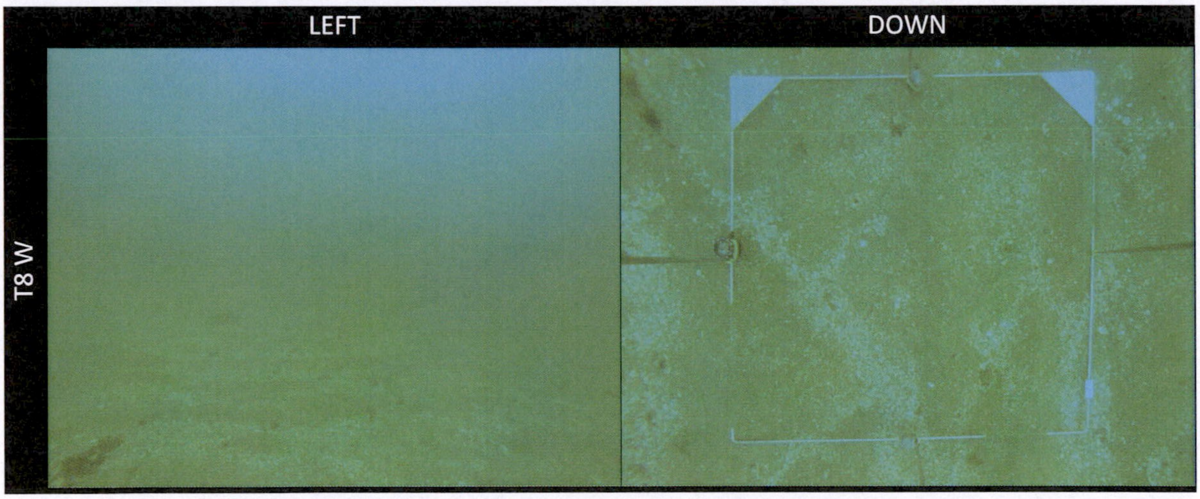
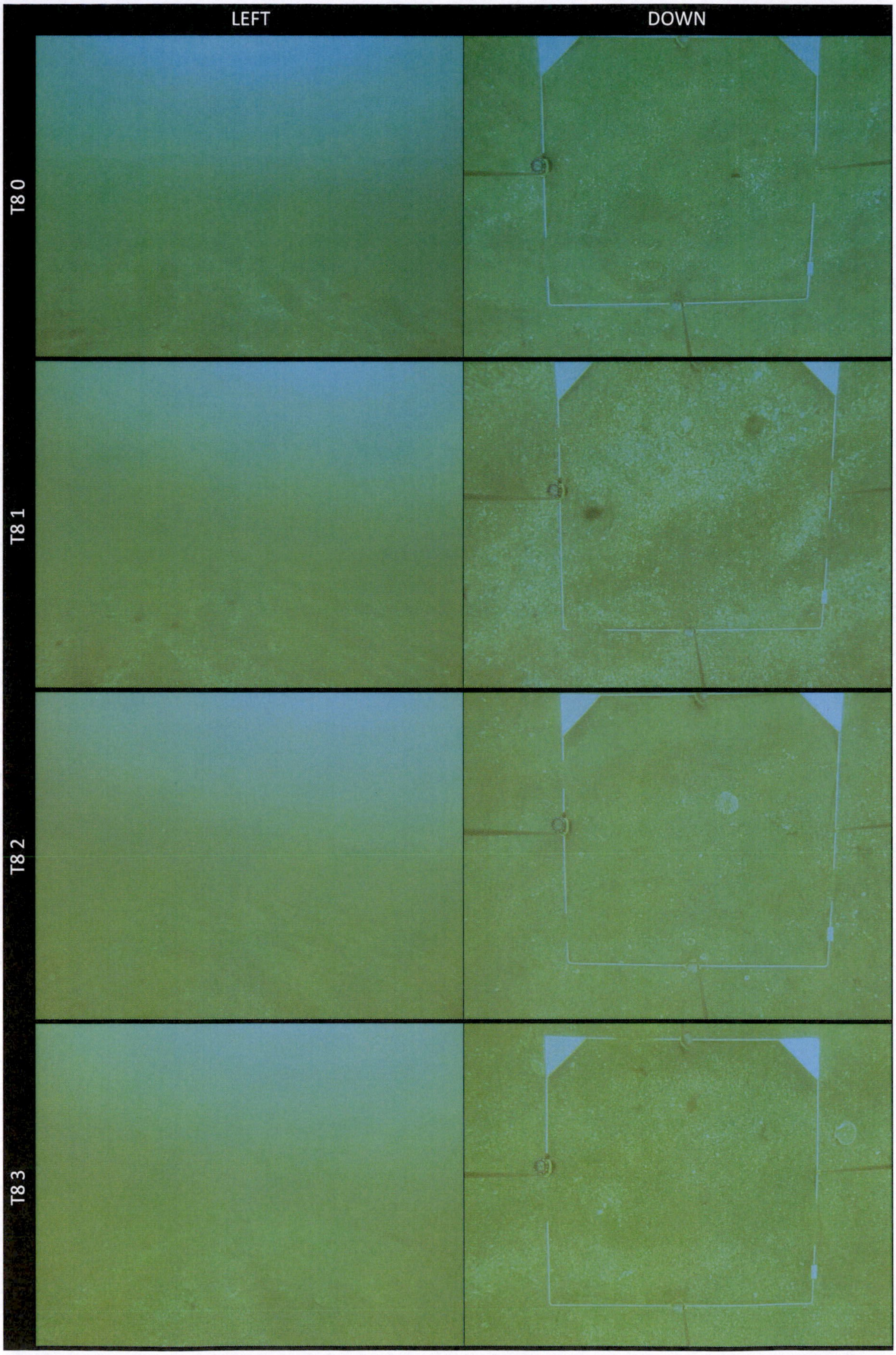


Figure 7.11 Drop Camera images from Transect T7, 18 December 2017




LEFT
DOWN
T8 0
T8 1
T8 2
T8 3

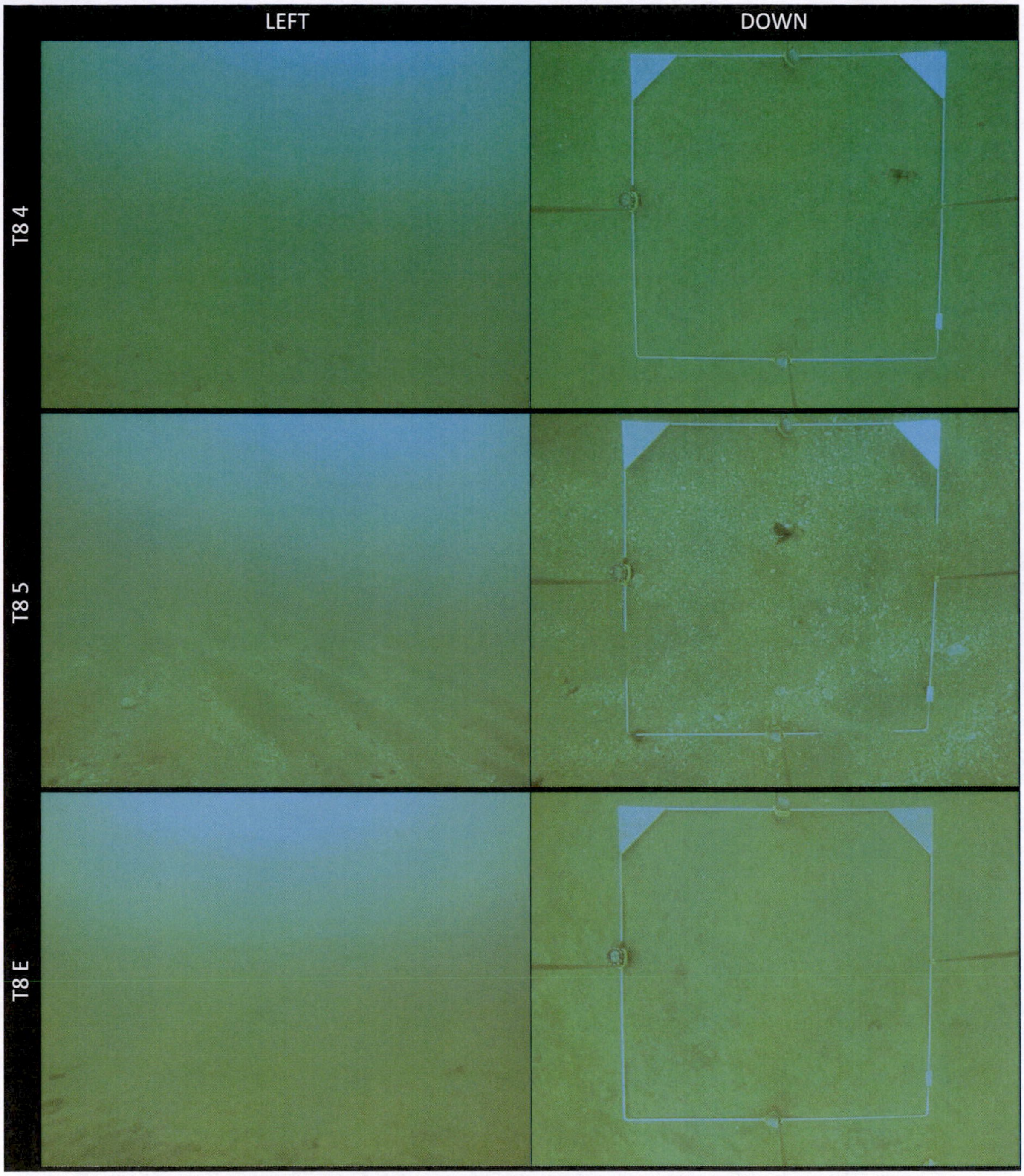
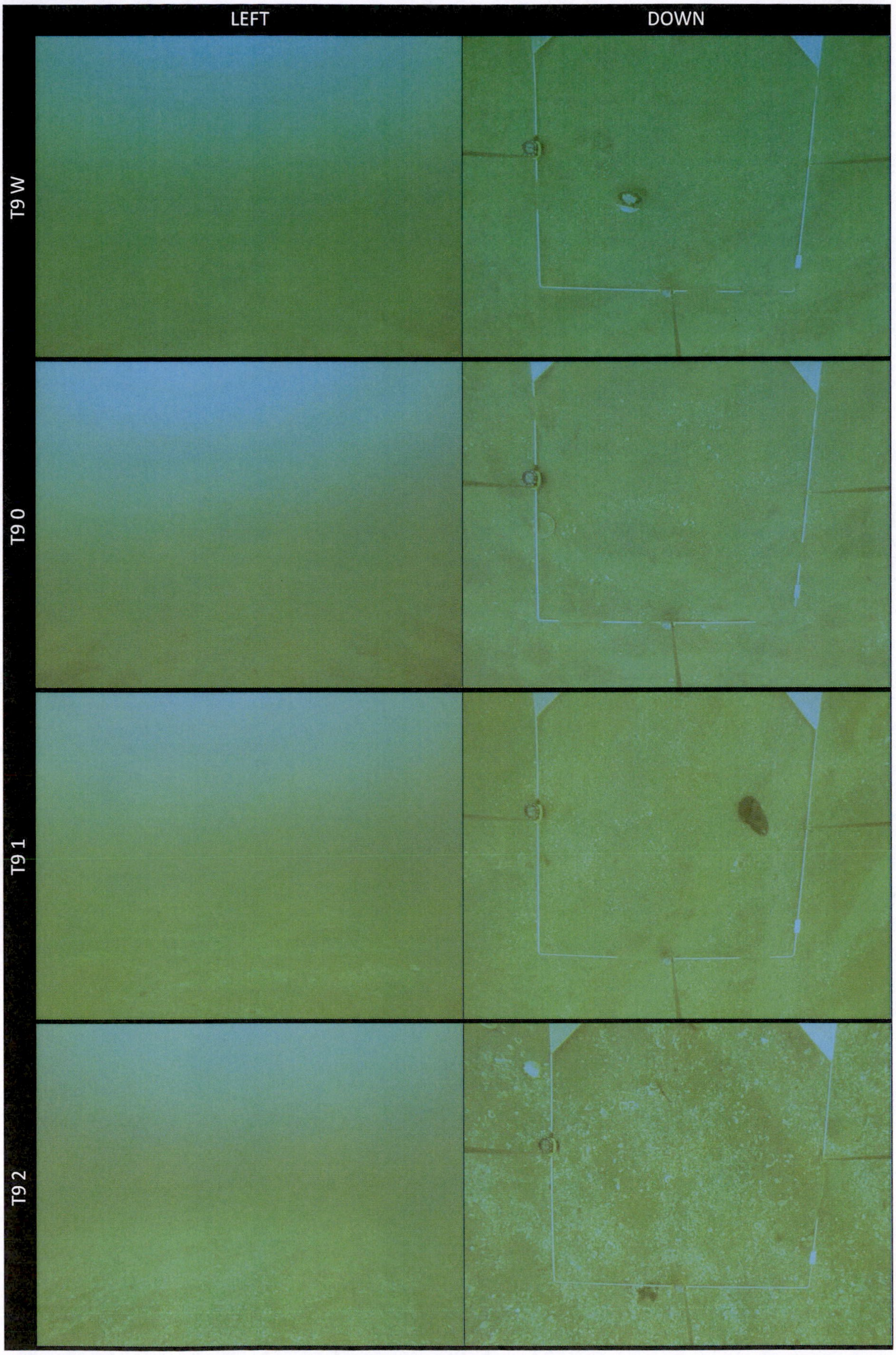


Figure 7.12 Drop Camera images from Transect T8, 18 December 2017


LEFT
DOWN
T9 W
T9 0
T9 1
T9 2

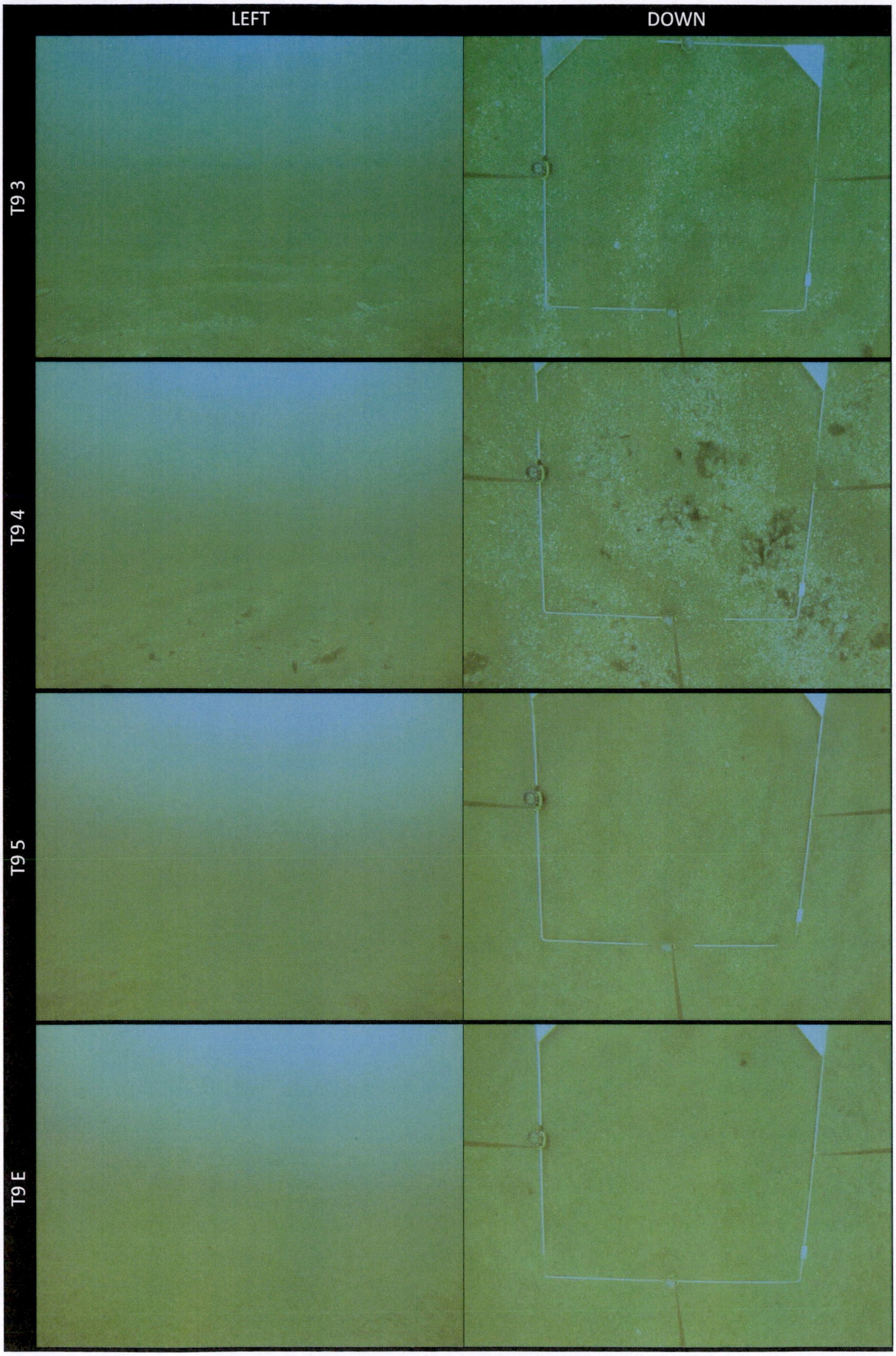


Figure 7.13 Drop Camera images from Transect T9, 18 December 2017

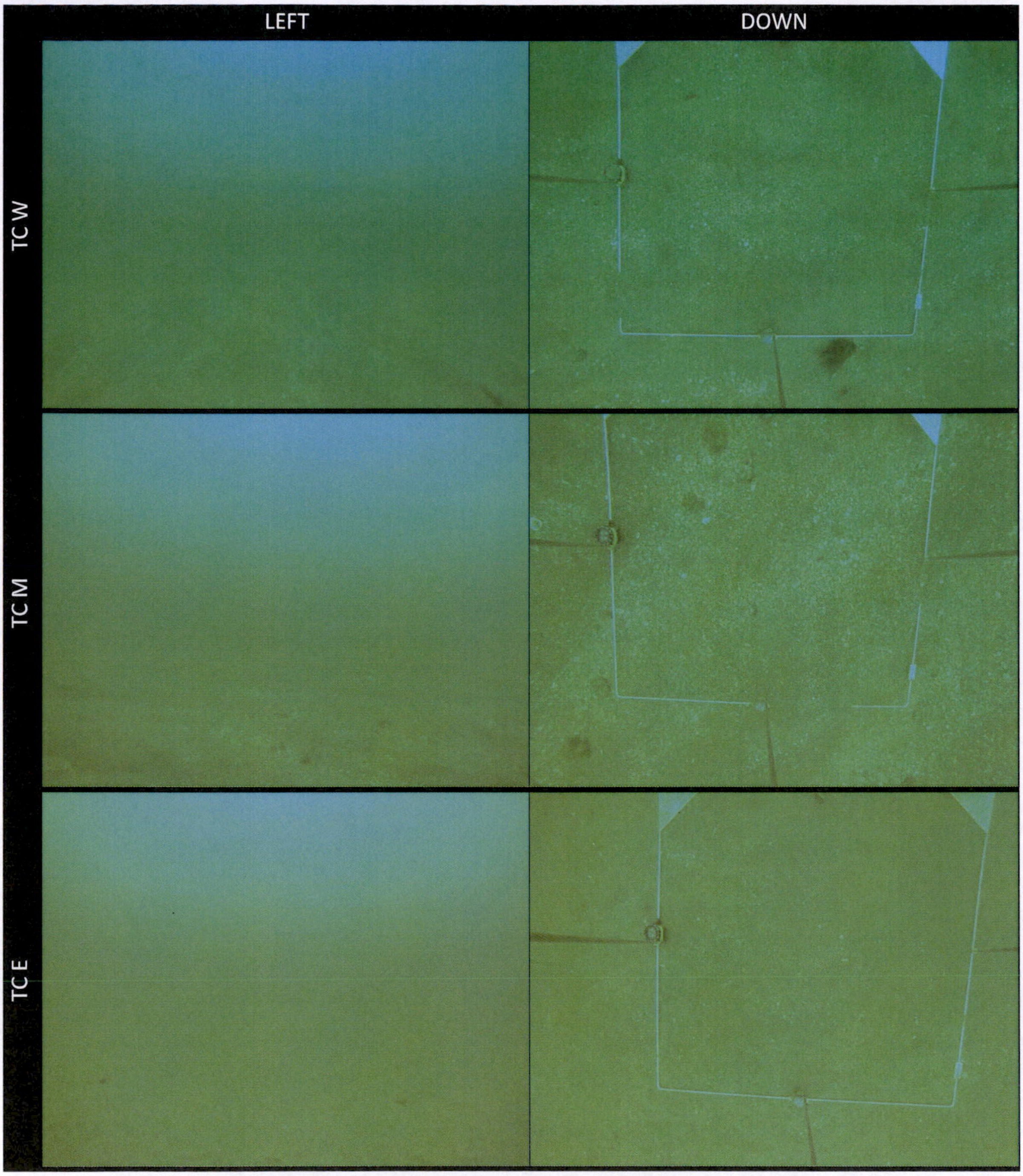
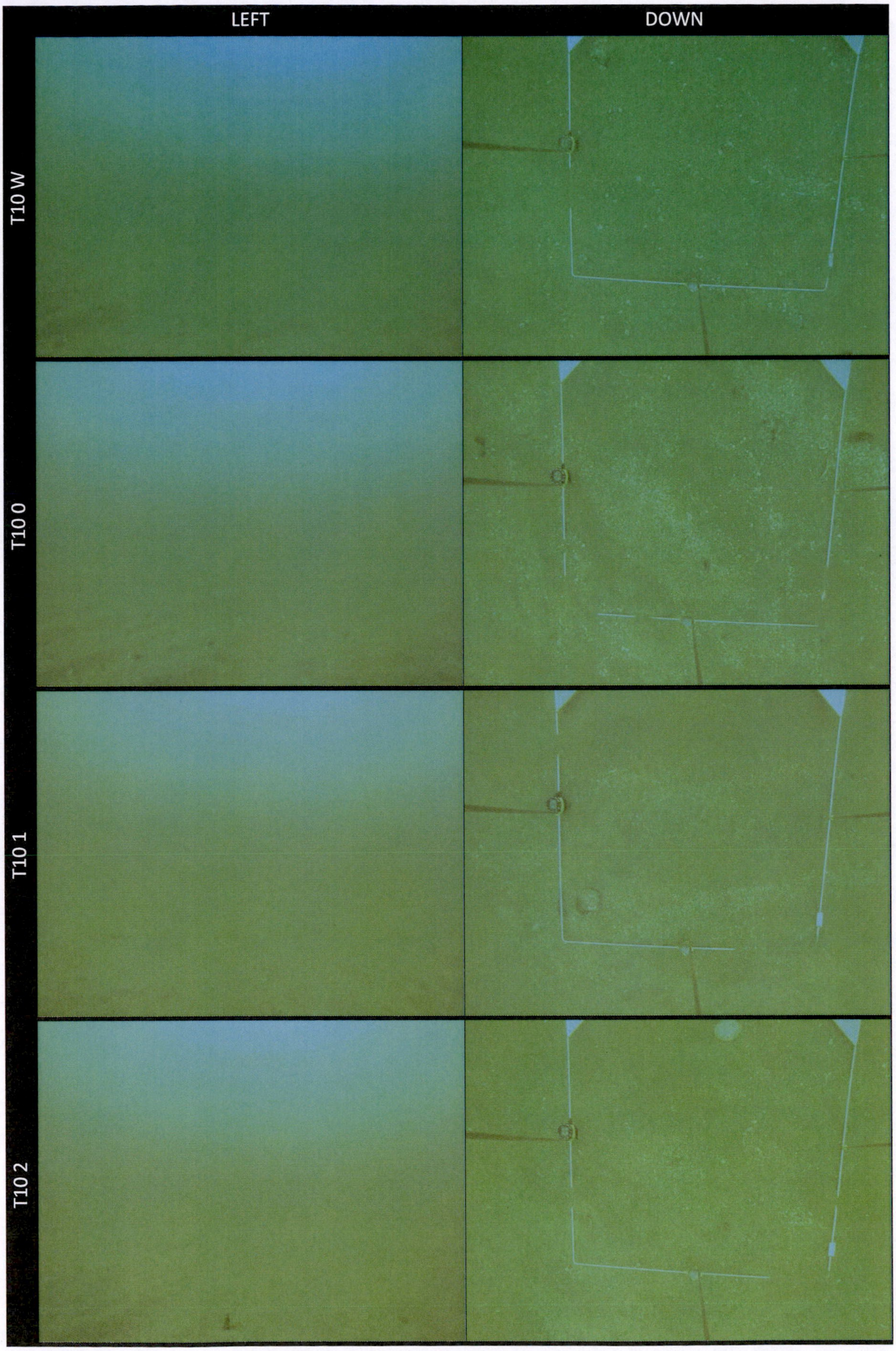


Figure 7.14 Drop Camera images from Transect TC, 18 December 2017


LEFT
DOWN
T10 W
T10 0
T10 1
T10 2

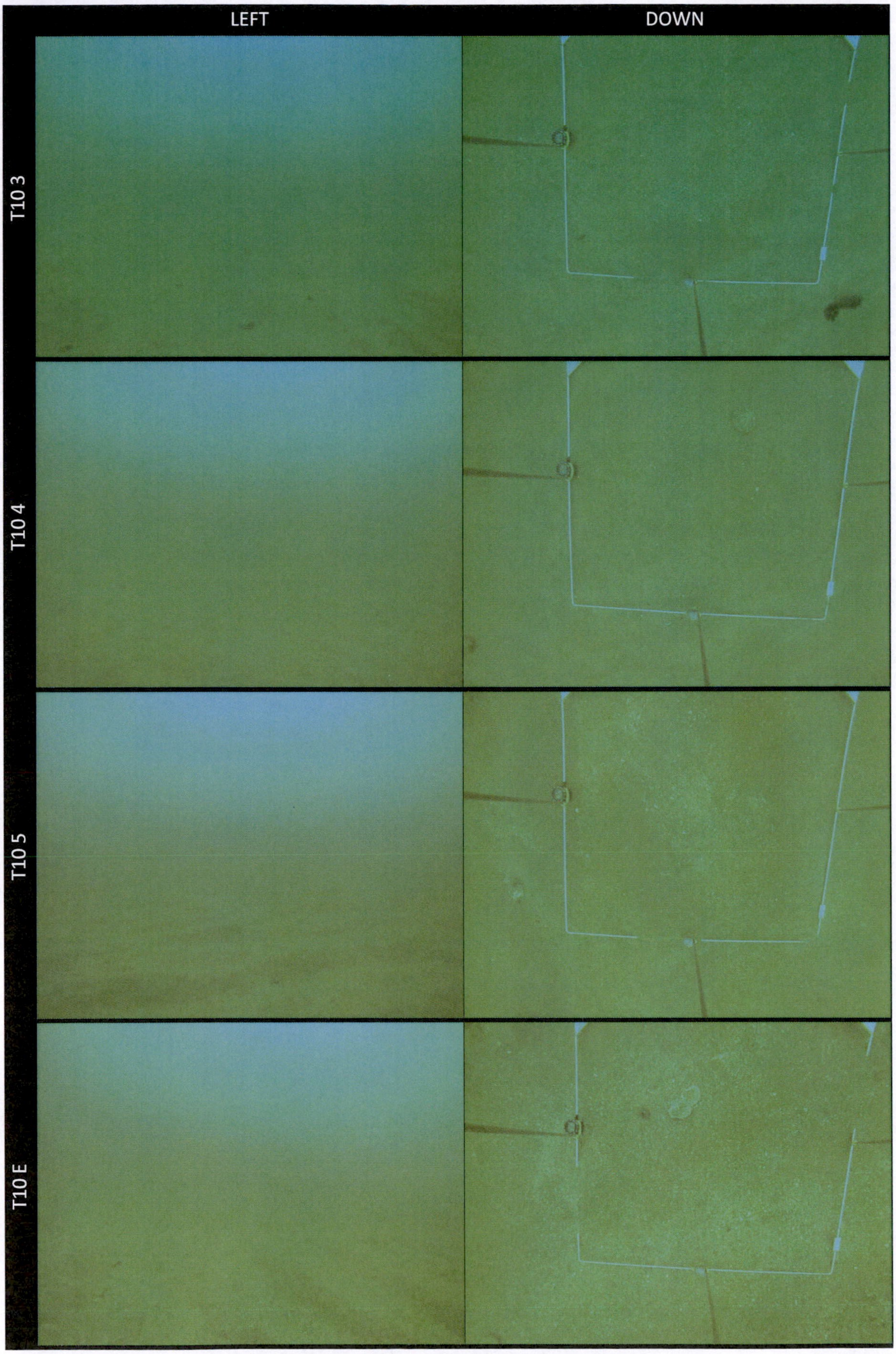


Figure 7.15 Drop Camera images from Transect T10, 18 December 2017

Table 21 Seabed photography summary descriptions, 2017.

Site	Comments		
TN W	Sand (80%), fine shell debris (18%), intact shell (2%)	no ripples uneven surface	
TN M	Sand (80%), fine shell debris (19%), intact shell (1%)	uneven ripples	Scallop
TN E	Fine shell debris (70%), coarse shell debris (10%), Sand (19%), intact shell (1%)	medium even ripples	finger sponge
T0 W	Sand (97%), shell debris (1%), crabs (2%)	uneven ripples	
T0 0	Sand (85%), shell debris (12%) with scallop shells (3%)	medium ripples	
T0 1	Sand (80%), coarse shell debris (15%), Scallop (5%)	medium ripples	Scallop
T0 2	Sand (85%), complete and fragmented shells (15%)	medium ripples	
T0 3	Sand (90%), fine shell debris (9%), cobble (1%)	medium ripples	
T0 4	Sand (95%), shell debris (5%)	uneven ripples	
T0 5	Sand (80%), shell debris (15%), complete shells (5%)	medium ripples	
T0 E	Sand (85%), shell debris (13%), complete shells (2%)	medium even ripples	
T1 W	Sand (75%), coarse shell debris (15%), intact shell debris (10%)	small uneven ripples	
T1 M	Sand (90%), fine shell debris (8%), intact shells (2%)	medium uneven ripples	
T1 E	Sand (60%), coarse shell debris (30%), intact shells (5%), sponge (5%)	medium even ripples	
T2 W	Sand (90%), fine shell debris (10%)	medium uneven ripples	
T2 0	Sand (85%), coarse shell debris (5%), intact shells (10%)	no ripples uneven surface (dimply)	
T2 1	Sand (40%), fine shell debris (30%), coarse shell debris (25%), large broken scallop shells (5%)	no ripples	
T2 2	Sand (78%), fine shell debris (5%), coarse shell debris (5%), intact shell (12%)	no ripples uneven surface (dimply)	
T2 3	Sand (95%), fine shell debris (3.25%), scallop shell (1%), sponge (0.75%)	medium ripples	
T2 4	NA		
T2 5	Sand (55%), coarse shell debris (37%), sponge (8%)	large ripples	
T2 E	Sand (60%), coarse shell debris (10%), intact shell debris (25%), seaweed (5%)	medium even ripples	
T3 W	Sand (85%), coarse shell debris (15%)	no ripples uneven surface	snapper
T3 M	Sand (83%), fine shell debris (7%), coarse shell debris (10%)	medium ripples	
T3 E	Sand (84.5%), coarse shell debris (15%), sponge (0.5%)	large even ripples	
T4 W	Sand (99%), shell debris (1%)	no ripples uneven surface (dimply)	
T4 0	Sand (90%), coarse shell debris (5%), intact shell (5%)	no ripples uneven surface	
T4 1	Sand (70%), coarse shell debris (20%), cobble (10%)	no ripples uneven surface	blue cod
T4 2	Sand (50%), coarse shell debris (50%)	large ripples	
T4 3	Sand (80%), fine shell debris (15%), coarse shell debris	medium ripples	
T4 4	Sand (90%), coarse shell debris (10%)	medium ripples	
T4 5	Sand (70%), coarse shell debris (20%), intact shell (5%), sponge (5%)	large even ripples	
T4 E	Sand (80%), coarse shell debris (20%)	large ripples	
T5 W	Coarse shell debris (85%), fine shell debris (5%), Sand (9%), snail (1%)	medium even ripples	
T5 M	Sand (80%), coarse shell debris (15%), intact shell (4.5%), seaweed (0.5%)	medium ripples	
T5 E	Sand (70%), fine shell debris (8%), coarse shell debris (12%), intact shells (10%)	medium even ripples	
T6 W	Sand (60%), mud/silt (20%), coarse shell debris (15%), seaweed (5%)	medium ripples	
T6 0	Sponge (50%), mud/silt (20%), coarse shell debris (15%), intact shell (10%)	flat surface	Blue cod
T6 1	Sand (40%), coarse shell debris (40%), fine shell debris (10%), intact shell (10%)	medium ripples	
T6 2	Sand (88%), fine shell debris (6%), coarse shell debris (5%), worm holes? (1%)	no ripples uneven surface	
T6 3	Mud/silt (75%), coarse shell debris (15%), intact shells (10%)	no ripples uneven surface	
T6 4	Sand (64%), mud (15%), coarse shell debris (22%), intact shells (8%), seaweed (1%)	medium even ripples	
T6 5	Sand (85%), shell debris (14%), worm hole (1%)	uneven ripples	
T6 E	Sand (80%), coarse shell debris (10%), fine shell debris (5%), seaweed (2.5%), sponge (2.5%)	medium ripples	
T7 W	Fine sand (80%), coarse shell debris (17%), seaweed (3%)	no ripples uneven surface	
T7 M	Mud/silt (20%), sand (70%), coarse shell debris (10%)	medium even ripples	

Site	Comments		
T7 E	Sand (60%), coarse shell debris (25%), fine shell debris (5%), intact shell (8%), seaweed (2%)	medium uneven ripples	
T8 W	Sand (70%), coarse shell debris (25%), seaweed (2%), intact shell (2%), worm holes (1%)	uneven ripples	
T8 0	Sand (80%), fine shell debris (10%), coarse shell debris (5%), intact shell (2.5%), worm holes (2.5%)	no ripples uneven surface	Scallop
T8 1	Sand (30%), fine shell debris (20%), coarse shell debris (40%), intact shell (2%), seaweed (5%), worm holes (3%)	medium uneven ripples	
T8 2	Mud/silt (30%), sand (50%), coarse shell debris (15%), intact shell (5%)	no ripples uneven surface	
T8 3	Sand (65%), fine shell debris (5%), coarse shell debris (25%), seaweed (5%)	medium parallel ripples	
T8 4	Fine sand/mud (90%), coarse shell debris (2%), seaweed (2%), worm holes (6%)	no ripples uneven surface	
T8 5	Sand (30%), coarse shell debris (50%), fine shell debris (15%), seaweed (1%), intact shell (4%)	medium ripples	
T8 E	Fine sand/mud (92.5%), intact shells (2%), seaweed (0.5%), worm holes (5%)	no ripples uneven surface	
T9 W	Sand (90%), fine shell debris (3%), coarse shell debris (1%), intact shell (6%)	medium ripples	Scallop
T9 0	Sand (92%), coarse shell debris (5%), fine shell debris (3%)	medium ripples	Scallop
T9 1	Sand (80%), fine shell debris (10%), coarse shell debris (2%), sponge (5%), wormhole (2.5%), seaweed (0.5%)	medium ripples	Scallop
T9 2	Coarse shell debris (80%), sand (15%), intact shells (5%)	medium uneven ripples	
T9 3	Sand (70%), coarse shell debris (5%), fine sand debris (20%), intact shells (5%)	medium ripples	
T9 4	Sand (50%), coarse shell debris (25%), intact shells (16%), seaweed (5%), sponges (4%)	medium ripples	
T9 5	Sand (90%), fine shell debris (9%), coarse shell debris (1%)	no ripples uneven surface	
T9 E	Fine sand/silt (90%), worm holes (2%), coarse shell debris (8%)	no ripples uneven surface	
TC W	Sand (85%), fine shell debris (10%), coarse shell debris (2.5%), seaweed (2.5%)	no ripples uneven surface	
TC M	Coarse shell debris (70%), sand (20%), intact shell (5%), seaweed (5%)	uneven ripples	
TC E	Fine sand (85%), coarse shell debris (10%), worm holes (5%)	no ripples uneven surface	
T10 W	Fine sand/silt (95%), coarse shell debris (3%), worm hole (2%)	no ripples uneven surface (dimply)	
T10 0	Sand (75%), coarse shell debris (20%), seaweed (3%), intact shell (2%)	medium uneven ripples	
T10 1	Sand (90%), fine shell debris (6%), worm hole (1%), intact shell (3%)	no ripples uneven surface	
T10 2	Sand (90%), coarse shell debris (5%), intact shell (4%), seaweed (1%)	medium uneven ripples	Scallop
T10 3	Sand (94%), fine shell debris (5%), seaweed (1%)	medium uneven ripples	
T10 4	Fine sand/silt (95%), shell debris (4%), intact shell (1%)	no ripples uneven surface	Scallop
T10 5	Sand (80%), fine shell debris (18%), coarse shell debris (2%)	uneven ripples	
T10 E	Sand (30%), coarse shell debris (70%)	medium even ripples	

Appendix 4 Benthic Biota results

Table 22 Benthic Biota Data Area 1 2003 (total number individuals recorded)

Taxa	A1
PHYLUM ANNELIDA	
CLASS POLYCHAETA	
Agalophamus macroura	14
Sigalionidae	11
Macroclymenella stewartensis	1
Lumbrineridae	8
Opheliidae	1
Orbiniidae	1
Phyllodocidae	1
Nereididae	6
Aphroditidae (sea mouse)	1
Glycera lamellipoda	14
Nephtyidae	1
Sabellidae	2
Polynoidae	41
Capitellidae	3
Notomastus spp.	8
Magelonidae	3
Magelona dakini	5
Spionidae	2
Scolecolepides sp.	1
Cirratulidae	5
Flabelligeridae	1
Pectinariidae	1
Terebellidae	1
Oligochaeta	2
Sipuniculidae	2
PHYLUM NEMERTEA	
Nemertian	9
PHYLUM ARTHROPODA	
CLASS CRUSTACEA	
ORDER AMPHIPODA	**177**
ORDER CUMACEA	
Cumacean sp.	90
ORDER DECAPODA	
Areopaguristes pilosus	57
Callianassa sp.	61
Halicarcinus spp.	3
Macropipus corrugatus	1
Ovalipes catharus	3
Manitis shrimp	1
ORDER ISOPODA	
Paranthura flagellata	7
ORDER MYSIDACEA	
Mysid sp.	42
ORDER OSTRACODA	
Ostracod sp.	1
PHYLUM MOLLUSCA	
CLASS GASTROPODA	
Antisolarium sp.	1
Cominella maculosa	1
Cominella spp	8
Sigapatella novaezelandiae	1
Tanea zelandica	1
Trochus tiaratus	1
Maoriculais roseus	2
CLASS BIVALVIA	
Arthritica bifurca	1
Corbula zelandica	33
Dosina crebra	10
Gari lineolata	1
Glycymeris modesta	4
Myadora striata	1
Nucula nitidula	6
Nucula harlvigana	3
Paphies australis	1
Soletellina silaqua	1
Thracia sp.	1
Venericardia purpurata	28
Unidid bivalve	2
PHYLUM ECHINODERMATA	
CLASS OPHIUROIDEA	
Amphiura sp.	1
PHYLUM CHORDATA	
CLASS LEPTOCARDII	
ORDER AMPHIOXIFORMES	
Epigonichthys hectori	23
Total Number of Species	**59**
Total Number of Animals	**719**

Site specific data unavailable

Table 23 Benthic Biota Data Area 2 2006 (total number individuals recorded)

Taxa	A2
PHYLUM ANNELIDA	
CLASS POLYCHAETA	
Nephtyidae	
Agalophamus macroura	7
Sigalionidae	7
Maldanidae	
Macroclymenella stewartensis	12
Onuphidae	
Onuphis (Nothria) sp.	
Eunicidae	8
Lumbrineridae	2
Opheliidae	2
Orbiniidae	5
Phyllodocidae	1
Nereididae	5
Glyceridae	1
Glycera lamellipoda	7
Sabellidae	1
Polynoidae	47
Capitellidae	
Notomastus spp.	12
Magelonidae	
Magelona dakini	9
Spionidae	1
Scolecolepides	1
Flabelligeridae	1
Pectinariidae	2
Terebellidae	3
Oligochaeta	7
Sipuniculidae	2
PHYLUM ARTHROPODA	
CLASS CRUSTACEA	
ORDER AMPHIPODA	**113**
ORDER CUMACEA	
Cumacean sp.	10

Taxa	A2
ORDER DECAPODA	
Areopaguristes pilosus	63
Callianassa sp.	22
Macropipus corrugatus	7
Ovalipes catharus	2
ORDER ISOPODA	
Paranthura flagellata	5
ORDER MYSIDACEA	
Mysid sp.	12
PHYLUM MOLLUSCA	
CLASS GASTROPODA	
Amalda australis	6
Cominella glandiformis	1
Sigapatella novaezelandiae	1
Maoriculais roseus	2
CLASS BIVALVIA	
Corbula zelandica	19
Dosina crebra	2
Glycymeris modesta	4
Limatula maoria	2
Pecten novaezelandiae	3
Myadora striata	1
Nucula nitidula	1
Paphies australis	2
Soletellina silaqua	2
PHYLUM ECHINODERMATA	
CLASS OPHIUROIDEA	
Amphiura sp.	1
PHYLUM CHORDATA	
CLASS LEPTOCARDII	
ORDER AMPHIOXIFORMES	
Epigonichthys hectori	12
Total Number of Species	**45**
Total Number of Animals	**436**

Site specific data unavailable

Table 24 Dredge Tow Data Area 2 2006

Taxa	No. individuals recorded	Taxa	No. individuals recorded
PHYLUM ANNELIDA		**PHYLUM MOLLUSCA**	
CLASS POLYCHAETA		**CLASS BIVALVIA**	
Notomastus spp.	1	*Corbula zelandica*	11
Eunicidae	1	*Gari convexa*	4
Glycera lamellipoda	2	*Glycymens modesta*	12
Magelona dakini	1	*Pecten novazelandiae*	94
Mauoclymenella stewartensis	2	*Myadora striata*	10
Aglaophamus macroura	1	*Paphies australis*	3
Oligochaeta	1	*Soletellina silaqua*	3
Opheliidae	1	*Tarea zelandica* (necklace shell)	2
Polynoidae	11	*Venericardia purpurata*	49
Spionidae	2	**CLASS GASTROPODA**	
Terebellidae	2	*Amalda australis*	11
PHYLUM ARTHROPODA		*Cominella glandiformis*	1
CLASS CRUSTACEA		*Cominella maculosa*	2
Amphipoda	33	*Cominella spp*	1
Cumacea	7	*Pelicaria vermis*	1
Shrimp	4	*Sigapetella novaezelandiae*	2
Brachyuran crabs	2	*Maoriculais roseus*	7
Macropipus corrugatus	7	**MISCELLANEOUS**	
Ovalipes catharus	1	Euphorid (brittle star)	10
Hermit crab *(Pagurus spp.)*	282	*Astropecten polyacanthus*	6
PHYLUM CHORDATA		**Total Number of Species**	**37**
NZ Lancelet *(Epigonichthys hectori)*	5	**Total Number of Animals**	**595**

Site specific data unavailable

Table 25 Benthic Biota Data Control Area, 2011 (Number per sample)

Taxa	CTS1												CTS2												
	00	01	02	03	04	05	06	07	08	09	10	11	00	01	02	03	04	05	06	07	08	09	10	11	12
PHYLUM ANNELIDA																									
CLASS POLYCHAETA																									
Nephtyidae																									
Agalophamus macroura												4									1	2			
Sigalionidae	2		3	1					1	2	1	1		2		4	3			1			1	1	1
Syllidae				2	1			1	1									1							
Maldanidae	5	2	3	4	2	24	2	1	11	2			2	16	14	6	9			20	8	4	4	2	
Cossuridae																									
Cossura sp				1																					
Dorvilleidae																		1							
Onuphidae																									
Onuphis (Nothria) sp.							1			1		1												1	
Paraonidae																									
Aricidea sp														1											
Phyllodocidae																	1								
Sabellidae						3		1												1					
Capitellidae			1					1			1							1							
Opheliidae																									
Armanida maculata								2		2				1				1							
Travisia olens					1																				
Spionidae																									
Malacoceros sp.												3													
Prionospio aucklandica																1									
Scolelepis sp.						3		1	1	1								1							
Cirratulidae														1				14			1				
Flabelligeridae												22													
Diplocirrus sp.										1															
Terebellidae												1								1					
PHYLUM NEMERTEA																									
Nemertian																1						1			1
PHYLUM PLATYHELMINTHES																									
CLASS TURBELLARIA																									
Polycladida													1												

Taxa	CTS1												CTS2												
	00	01	02	03	04	05	06	07	08	09	10	11	00	01	02	03	04	05	06	07	08	09	10	11	12
PHYLUM ARTHROPODA																									
CLASS CRUSTACEA																									
ORDER AMPHIPODA																									
Ampeliscidae												1													
Corphioidea										2															
Gammaridae		1						5	1	5	1							1							
Haustoriidae			1		1	4				1	1	1	2	1		1	1	1				1			
Liljeborgiidae																									
Liljeborgia sp.				1				1		2	1					1						2			
Lysianassidae			1				1	2				1								1					
Phoxocephalidae																									
Phoxocephalidae H A		1	2										3	2								1			
Phoxocephalidae H B		1			1	1								1		3							1	1	
Phoxocephalidae H C																1		1			1		1	1	
Phoxocephalidae S A	2		1	1		1							4	2	3	2	4					2	5	2	1
Phoxocephalidae S B													1	2							1				
Phoxocephalidae S C										1		1	1			2									
ORDER CUMACEA																									
Cumacean sp.									1								1								
ORDER DECAPODA																									
Crab zoea						1																1			
Areopaguristes pilosus			2					4	2	2	1	5	1					6		1		2		1	
Callianassa sp.		1										7										1			
ORDER ISOPODA																									
Paranthura flagellata											1			1								2			
ORDER MYSIDACEA																									
Mysid sp.												1													
ORDER TANAIDACEA																									
Tanaid sp.												1													
ORDER OSTRACODA																									
Ostracod sp.													1												
PHYLUM MOLLUSCA																									
CLASS GASTROPODA																									
Antisolarium sp.												1													1
Cominella quoyana								2																	
Sigapatella novaezelandiae								1																	
CLASS BIVALVIA																									
Corbula zelandica										1								1							
Cuna mayi																			1						
Dosina crebra																			1						
Dosinia subrosea							1																		
Gari lineolata																	1				1				
Myadora striata														1											
Myllitella vivens					2																				
Notocallista multistriata																					1		1		
Nucula nitidula	4	3	1							1		2	1	2			1	1		1	1			2	
Scalpomactra scalpellum											1												1		
Tawera spissa	1		1	1	2	1							4	16	2	2									
Thracia sp.			1																						
Venericardia purpurata													1			1		1	1						
PHYLUM ECHINODERMATA																									
CLASS OPHIUROIDEA																									
Amphiura sp.															1										
PHYLUM CHORDATA																									
CLASS LEPTOCARDII																									
ORDER AMPHIOXIFORMES																									
Epigonichthys hectori																			3						
PHYLUM PORIFERA																									
CLASS DEMOSPONGIAE																									
ORDER AXINELLIDA																									
Homaxinella erecta								1										1	1						
ORDER HADROMERIDA																									
Unidet radial sponge																		1							
Total Number Of Species/Taxa	5	6	11	7	7	8	4	13	7	14	8	16	12	14	4	12	8	15	5	7	8	11	7	8	4
Total Number Of Individuals	14	9	17	11	10	38	5	23	18	24	8	53	22	49	20	25	21	33	7	26	15	19	14	11	4

Table 26 Dredge Tow Data Control Area 2011

Site	Common name		Size								n	Average	St. Dev.
A	Scallop	*Pecten novaezelandiae*	91	73	86	71	86	72	44	41	8	70.50	17.61
	Purple Cockle	*Venericardia purpurata*	32	28	30	28					4	29.50	1.66
	Hermit		1								1	-	-
	Comb Star	*Astropecten polycanthus*	116	117	109	111	93	97	137	112	8	111.50	12.55
	Carrier shell	*Xenophora neozelanica*	63								1	63.00	-
B	Scallop	*Pecten novaezelandiae*	74	82	76	89					4	80.25	5.85
	Hermit		1								1	-	-
	Comb Star	*Astropecten polycanthus*	110	126	108	111	127	130	125		7	119.57	8.73
	Starfish	*Luidia varia*	148								1	148.00	-
C	Carrier shell	*Xenophora neozelanica*	44								1	44.00	-
		Mesopeplum convexum	38								1	38.00	-

Table 27 Benthic Biota Data Area 1 North, 2017 (Number per sample)

Taxa	Transect	TN			T0								T1			T2								T3			T4							
	Site	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
Phylum Annelida																																		
Class Polychaeta																																		
Order Sabellida	*Euchone pallida*	2											2	2			3	2	2					12			2	11	3		1		1	
	Sabellidae		1	1	1						1		3	1			1							4		5							1	
	Hydroides sp.																																	
	Serpula sp.																								1									
	Serpulidae																																	
Order Spionida	*Phyllochaetopterus socialis*	1															1											2						
	Aonides oxycephala																																	
	Boccardia sp.																																	
	Paraprionospio pinnata	3															2	1	1			1		6						1				
	Prionospio aucklandica																																	
	Prionospio multicristata	1		8																							1	2	37	9	13	7	2	
	Prionospio sp.	10	4	35	37	7	19	3	8	8	26	36	33	38		2	10	17	11	2	2	16		2	4	4	9	2	52	33	31	10	4	1
	Spio sp.				1									1	1				1					1		1								
	Spiophanes kroyeri	2			7	6				4	1	2					2		4		2							9	3			1		
	Spiophanes modestus	129	4		12	79	14	3	1	2	1		16	2		18	102	46	80	2	2		1	236	4		185	145	253	12	8	1	3	
Order Terebellida	Ampharetidae	10	1	4	4		1			1	5	12		1	2		1	2			1			26		1	2	1	4	2		2	5	2
	Cirratulidae			2	1	4	1			1	3	3	4	1	1	1	4	1	1	2				4	1	1			2	1	1		4	
	Flabelligeridae																																2	
	Lagis australis																1												2					
	Terebellidae	5	1	1	7	4				7	3	18	5	7	3		7	4	2	3	4	2	5	6	5	12	1	16	1		13	17	9	5
Order Eunicida	Dorvilleidae												2	1						2											1	1		1
	Marphysa sp.																						1										1	
	Lumbrineridae			3														1									1						1	2
	Nothria sp.	3	1	7										1	2		4		10	14	2		3	8	1	24	2	78	12		4	28	29	8
	Onuphis aucklandensis		1																					2				2						
	Onuphidae				1	1	1			5	7	5																						
Order Phyllodocida	Glyceridae	2				1								1										1										
	Goniadidae	1			1				1								10	8	6			1		11				5	8	1	1	1	3	
	Hesionidae				2						1	2			1		5	5		1				2	1									
	Aglaophamus sp.	1	1			3										1				1		1												
	Neanthes cricognatha																			1														
	Perinereis vallata																																	
	Phyllodocidae	4	2	3	3	4	4	1		3	2	2				2	5	3	7					12		1	5	9	8		4		1	
	Polynoidae																																1	
	Sigalionidae	2	2	3	2	3	8	2		6	1	2	7	2		2		2	4		2	1	1	3		6	2	4		1	3		3	
	Sphaerosyllis sp.			6	3	1	1			4	11	5	5	2	1		4	5	4	4	1	4	1	3	1		4		6				4	2
	Syllidae	2	1	7	2	5	12	3	2	6	13	2	3	5	3	1	1	1		6	1		2	7	3	9		2	1		1	2	2	2
	Magelona dakini	1	2		1	1	1		1	2	5										1		1							1				
Order Capitellida	*Barantolla lepte*													3							1					2				2			1	
	Capitella capitata																																	
	Heteromastus filiformis										1	3																						
	Notomastus zeylanicus				1				1		1	1		1									1						1		1	1	3	1
Order Cossurida	*Cossura consimilis*																																	
Order Opheliida	*Armandia maculata*	11		6	8	2	1				6	11	4				3	11	1			1		5		1	4	6	7	6	5	3	5	
Order Orbiniida	*Leodamas cylindrifer*																1							1		1							1	
	Orbinia papillosa				2																											2	2	
	Maldanidae	4		1	5	8	1	1			6	1	4	2		4	16	4	4	1			1	15	4	1	18	66	10		1	1	4	
	Aricidea sp.	2				1											1															1		
	Paraonidae					1	2						2			1	1							2	1									
	Travisia sp.	2			2				1									1						1			2		3	1				
Phylum Hemichordata																	2	2	1					1				1						
Phylum Cephalorhyncha	Priapulidae																																	
Phylum Phoronida	*Phoronis sp.*	2				5					1		1			2		1						3			1	5	1		1	1		
Phylum Nemertea				1								2	1		1		1	1	1	1				1				1	6	1			2	
Phylum Arthropoda																																		
Class Hexanauplia	Copepoda	2			1	3	2	1	1	2	1						2						2		3				1					
Class Malacostraca																																		
Order Amphipoda																																		
	Caprellidae	1				1		2																3	1		1	1	14					
	Haustoriidae	1			5	7	6	3	2	1	3	1			1	7	4		4	3	1	6	1	3	3	3	27	7				1	3	
	Lysianassidae	3	1	1	8	10	7		2	1	3	8	2	1	1	7	6	9	24	1		3		2	4		16	7	35	1	1	6	8	
	Oedicerotidae												1	2		1			2															
	Phoxocephalidae	4	6	9	5	25	10		3	2	3	5	2	5	2	16	6	12	15			6		8	5	4	12	6	10	3		5	1	
	Stegocephalidae									1		1																						
	Talitridae																			1									2					

Taxa	Transect	TN			T0								T1			T2								T3			T4							
	Site	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
	Amphipoda Unid.	154	21	138	135	163	144	32	20	78	142	219	268	66	16	23	356	506	277	12	15	25	30	368	131	42	149	125	1153	239	22	62	63	17
Order Cumacea		36	23	13	23	72	13	5	10	10	10	6	9	15	3	6	40	33	12	6	3	48		31	4	3	2	7	15	20	3	2	3	2
Order Decapoda																																		
	Alpheus sp.		1																															
	Philocheras australis	1																																
	Halicarcinus cookii																																	
	Halicarcinus sp.				1																													
	Ebalia laevis			1							2							2	1			1												
	Notomithrax sp.																						1						2					
	Natantia Unid.																					1	1											
	Nectocarcinus antarcticus									1																						1	1	
	Pagurus sp.	5		3		3	4	1	2	5	1	3	10	3			11	24	8	1	2			10	12	2	1	2	36	76	45	7	13	
	Nepinnotheres novaezelandiae																												1					
	Liocarcinus corrugatus																	2						1		1							1	
	Petrolisthes novaezelandiae																1																	
	Processa sp.																	1																
	Upogebia sp.																									1								
	Decapoda (larvae Unid.)	4				11	6		1	1	1	3	1	3			1	1						1		1		1	5			1	2	
Order Isopoda																																		
	Anthuridae	2		3	4	1		1			3	2	9	1			8		4		3			2	5			6	3		1			
	Eurylana arcuata		1						1	1					1								1			1						1		1
	Pseudaega sp.																																	
	Munna neozelanica							1						1																				
	Uromunna schauinslandi	1				2					1	2					2		1			1	3	4		2			7				2	
	Cassidina typa																																	
	Exosphaeroma sp.																																	
	Paravireia sp.			2																1						1								
	Valvifera										1																							
Order Leptostraca	*Nebalia sp.*									1																			4					
Order Mysida		4					3		1	2					1													1		2	1	1		
Order Podocopida	*Paracypris zealandica*	54			5	32	19	4					86	2		6	12	24	77			1							109					
Order Stomatopoda																				1		1												
Order Tanaidacea			1	1		1		4			3	4	2	3			1	1	2		1	1	1	6	2	3		2	14				1	1
Class Ostracoda																																		
	Diasterope grisea	4			2	7	3	5		1		1	7	1	1		10	4	2	2	1	3		1	1		8	6	17	2			1	1
	Leuroleberis zealandica											1									1			78	2						1			
	Parasterope quadrata			1			3	1		3	2	1	3	2	1		2	7	3			1		14		1	2		39	1			2	2
	Cypridinodes sp.	4	10	14	13	10	12	22	7	24	20	43	22	19	8	2	35	12	16	10	9	5	3	11	16	5	13	5	99		1	6	9	6
	Pleoschisma agilis			1		1				2	3	1	6	1		2	2	8		2			1	1	1		12	4	4					
	Scleroconcha sp.						1			1				1			1								1		2		1					2
	Cymbicopia sp.		4	2	3	4	3	2	1	5	3	3	16	5		1		3	3	2	1	5	3	3	5	2	2		9	1			1	3
	Copytus novaezealandiae																																	
	Bradleya sp.		1	1														2		1	1	1					1		3					
	Ostracoda							2		1																								
Phylum Mollusca																																		
Class Polyplacophora																																		
	Ischnochiton maorianus												2					5																
	Leptochiton inquinatus						1				1	2																						
Class Gastropoda																																		
	Epitonium sp.									1							1																	
	Maoricolpus roseus	1		1			1	1		1						1				3	1		1		1	1	2							
	Zeacolpus sp.																																	
	Philine sp.																1																	
	Relichna aupouria		1	1																							1							
	Caecum digitulum																																	
	Sigapatella tenuis			1		2	9				1	2	2	1			3	12	1						1				1		1			
	Sigapatella sp.																																	
	Merelina sp.																																	
	Tanea sp.																1																	
	Naticidae																					5												
	Rissoidae	2																																
	Struthiolaria papulosa																																	
	Tonna sp.															1																		
	Amalda northlandica					1										1	1		1			1						1	1					
	Amalda sp.																							1										
	Austrofusus glans																1										1							
	Cominella quoyana																	1						1										
	Cominella virgata	1		2	1		1					2							2										2					
	Splendrillia aoteana																																	
	Marginellidae															1																		
	Zeatrophon ambiguus										1						1	2																
	Turbonilla sp.																																	

Taxa	Transect	TN			T0								T1			T2								T3			T4							
	Site	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
	Pyramidellidae							1																										
	Pleurobranchaea maculata																	1																
	Onchidella nigricans																																	
	Cantharidus sp.					1	1																											
	Adelphotectonica reevei							1		3							2									1								
	Gastropoda Unid. Juv.		1					1	2	2	1		1				1		2					2					2				1	
Class Bivalvia																																		
	Hunkydora novozelandica																																	
	Myadora antipodum																																	
	Myadora striata						1								1																			
	Glycymeris modesta															1																		
	Glycymeris sp.					1	1																											
	Pratulum pulchellum	1		1							2	1					3	1											1					
	Gari lineolata							1													1				1				1					
	Hiatula sp.			1	1	8						1						10							1		2		7					
	Pleuromeris zelandica						1																											
	Pleuromeris sp.																																	
	Purpurocardia purpurata																																	
	Limatula maoria			3		1			1		1							1																
	Corbula zelandica			3							7	3			1					2	1					2						5	11	1
	Nucula nitidula				4		1					4	2					20	1					1		1			2				3	1
	Atrina zelandica	1											1				1		1					1										
	Pecten novaezelandiae										1																							
	Dosinia lambata																		1															
	Dosinia subrosea																													1				
	Dosinia sp.																								1		2							
	Notocallista multistriata																		1					1		1					1			
	Tawera spissa																																	
	Tawera sp.					1	1			1						1	1	5									2							
	Arthritica bifurca																																	
	Myllita vivens															1																		
	Mysella sp.	4			1	2		1										1	2					3	1				1				1	
	Scalpomactra scalpellum																											1						
	Diplodonta zelandica																2																	
	Bivalvia Unid. (juv)					1	1			1		1						1	1		1													
Phylum Echinodermata																																		
Class Echinoidea	*Echinocardium sp.*	1		2	4		2										6	5	2			2		2					1					
Class Ophiuroidea		1								1	1					1	2	2					8		1	1		1					1	
Phylum Cnidaria																																		
Class Anthozoa																																		
	Anemone (unid.)	2																											3					
	Edwardsia sp.																																	
	Arachnanthus sp.																					1												
Order Scleractinia																																		
Class Hydrozoa																																		
	Hydroida (thecate)																												1					
Phylum Sipuncula																																		
	Aspidosiphon sp.																																	
	Nephasoma sp.																				1													
	Phascolion sp.																																	
	Themiste sp.											1																						
Phylum Bryozoa																																		
	Bryozoa (bushy)										1																							
	Bryozoa (discoid)																																	
	Bryozoa (encrusting)																				1								2					
Phylum Porifera																																		
	Sponge (bread)													1							1												1	
	Sponge (cream Encrusting)																																	
	Sponge (glass)																																	
Phylum Chordata																																		
Class Ascidiacea																																		
	Eugyra sp.								1				1	1												1								
	Molgula sp.			1																														
	Pyura sp.																												1		1			
Class Leptocardii	*Epigonichthys hectori*	3				2	2		2	2	4		1		1	1	3	2	3	1	1	3		5			5	3	4	2			3	1
Class Thaliacea	*Salpa sp*	7	1		11	34	16	3	7	15	2	7	9	5	4	3	11	14	6	1	1	3	1	5		3			13	1			1	
Total Number of Individuals		504	93	294	330	543	341	108	79	219	320	435	555	210	57	117	729	852	615	90	66	151	74	944	229	152	502	553	2046	420	167	177	227	62
Total Number of Species/Taxa		49	25	39	39	46	42	28	24	41	48	43	38	38	23	30	59	53	46	30	31	30	24	54	34	37	36	37	59	25	27	28	48	21
Shannon Wiener Diversity Index		2.406	2.483	2.298	2.494	2.595	2.529	2.570	2.617	2.705	2.524	2.189	2.123	2.579	2.629	2.759	2.254	2.026	2.209	2.969	2.965	2.515	2.376	2.230	2.004	2.781	2.092	2.366	1.916	1.555	2.395	2.385	3.001	2.569

Table 28 Benthic Biota Data Area 1 South, 2017 (Number per sample)

Taxa	Transect	T5			T6								T7			T8							
	Site	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
Phylum Annelida																							
Class Polychaeta																							
Order Sabellida	*Euchone pallida*		2	1	1	1	2							1					1	4	3	2	1
	Sabellidae		2	6								1									2		3
	Hydroides sp.							1															
	Serpula sp.							4							4								
	Serpulidae														4								
Order Spionida	*Phyllochaetopterus socialis*																			1			
	Aonides oxycephala																					1	
	Boccardia sp.							1			1												
	Paraprionospio pinnata				3	1						3		1							2		
	Prionospio aucklandica																						
	Prionospio multicristata	4				1	3	4	4		2	2		8	4	3	2	1	1	3	1	2	
	Prionospio sp.	15	8		6	8	26	34			15	9	2	8		2	6	2	7	37	4	13	8
	Spio sp.					1		1	1				2	2		1	1	1	1		1	3	
	Spiophanes kroyeri	1			1			1						1						2			
	Spiophanes modestus	1		2	176	29	29	186			8	208		124	3	1			14	94	206	4	248
Order Terebellida	Ampharetidae			8	6	12	3	33	1			51		4	1			3	1	12	184	2	87
	Cirratulidae		1	2	1	6	3	2			2	3	2	3		1			1	1	4	1	5
	Flabelligeridae																					1	
	Lagis australis																						
	Terebellidae	1		3	3	10	1	5	1			7	2	1		4	4	2	1	7	3	2	
Order Eunicida	Dorvilleidae	1				2	1				1												
	Marphysa sp.																						
	Lumbrineridae	2							2				1			7	1	1				1	1
	Nothria sp.			8	1	4	1	1		2	1	17	1	1						4	11	6	6
	Onuphis aucklandensis																						
	Onuphidae																						
Order Phyllodocida	Glyceridae						1		1		2	3									2		
	Goniadidae				4	16	4	5				5					1			6	18		12
	Hesionidae				1	2	1								1	1			1	1	1	1	
	Aglaophamus sp.			1	2			1	1							1				2			1
	Neanthes cricognatha																						
	Perinereis vallata																						
	Phyllodocidae		1	1	9	7	1	6			1	4	1	3	4	1	2		1	1	8		8
	Polynoidae			1			1					1											1
	Sigalionidae	4	3		1	1	1	5	1	5	3	1		2	1	2	2	2	2	1	1	4	1
	Sphaerosyllis sp.	1				1	1				1					4		1				1	
	Syllidae	2		1		2	1				6	1	2	1	3	5	3			3		1	
	Magelona dakini						1		2	1						1	1		1			2	1
Order Capitellida	*Barantolla lepte*			4										1		1				5		1	
	Capitella capitata							1															
	Heteromastus filiformis																						
	Notomastus zeylanicus						2	1			1												
Order Cossurida	*Cossura consimilis*																					1	
Order Opheliida	*Armandia maculata*	1	2		8	14	8	15		1		5		2		1	1	1		7	3	1	1
Order Orbiniida	*Leodamas cylindrifer*				4							2											2
	Orbinia papillosa						1														1	1	1
	Maldanidae	5		1	28	5		6			1	2	1	3		5	7	1	1	3	6	2	1
	Aricidea sp.							1				2		1							2		7
	Paraonidae																						
	Travisia sp.	3			1		2		1							5					2		
Phylum Hemichordata																			1		1		
Phylum Cephalorhyncha	Priapulidae																				1		
Phylum Phoronida	*Phoronis sp.*					1		1				2				1			1		1		5
Phylum Nemertea			1		2		1			1					1				1	1	2		3
Phylum Arthropoda																							
Class Hexanauplia	Copepoda	1																					
Class Malacostraca																							
Order Amphipoda																							
	Caprellidae														1	2							
	Haustoriidae				13	1	2	10			1	4	1	14		1			3	1	14		13
	Lysianassidae	1		1	65	4	1	64	1		10	26		18		2	3	1	4	8	12	2	2
	Oedicerotidae			1																			
	Phoxocephalidae	4	4	3	83	19	7	70	2		1	17	5	70	3	6	15	1	7	9	22	4	5
	Stegocephalidae										1											1	
	Talitridae																						
	Amphipoda Unid.	43	23	55	136	121	162	136	16		292	22	22	70	15	12	13	7	32	185	22	125	9
Order Cumacea		10	4	21	63	10	5	44	7		3	202	5	63		4	20	4	15	6	36	9	33
Order Decapoda																							
	Alpheus sp.	1																					
	Philocheras australis																						
	Halicarcinus cookii																						
	Halicarcinus sp.																						
	Ebalia laevis						1				1	2									2		1
	Notomithrax sp.																						1
	Natantia Unid.																						
	Nectocarcinus antarcticus										1												
	Pagurus sp.	24	2	2	8	15	17	12	3		2	4	7	8	228	5	5	3	4	19	3	3	1
	Nepinnotheres novaezelandiae				1																		
	Liocarcinus corrugatus					1														1			
	Petrolisthes novaezelandiae																						
	Processa sp.																						
	Upogebia sp.																						
	Decapoda (larvae Unid.)	1	1	2		1		3						1		1					1	1	1
Order Isopoda																							
	Anthuridae	3	1	1	1	2	3	4	1		2		1	1		3	1	3	2	5	5	2	2
	Eurylana arcuata				1				1	1	3		1	1				1					
	Pseudaega sp.																						
	Munna neozelanica															1							
	Uromunna schauinslandi						2	2													3		
	Cassidina typa																						
	Exosphaeroma sp.				1																		
	Paravireia sp.										3												
	Valvifera													1	8								
Order Leptostraca	*Nebalia sp.*			1																	1		1
Order Mysida		1			4	1		2	1							5		1			1		
Order Podocopida	*Paracypris zealandica*				2	27	1	43					2	40	2		5			30	18	3	7
Order Stomatopoda				1																			
Order Tanaidacea					4	2		9	1		2	3			1		2	2	2		2	1	8
Class Ostracoda																							
	Diasterope grisea	1			4	23	1	3	1			1	4	1	1	2	5	1	1	2			1
	Leuroleberis zealandica																						
	Parasterope quadrata	1			6	6	4	3			3			1			1			2		1	1
	Cypridinodes sp.	11	1		20	21	4	7			16	2	7	6	1	4	3	4		7	34	9	26
	Pleoschisma agilis						1	3													5	1	
	Scleroconcha sp.														2					1			1

Taxa	Transect	T5			T6								T7			T8							
	Site	W	M	E	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
	Cymbicopia sp.	3				3	2		1		5		4		1	2	5			1			
	Copytus novaezealandiae					1	1																
	Bradleya sp.													4	4								
	Ostracoda																						
Phylum Mollusca																							
Class Polyplacophora																							
	Ischnochiton maorianus												1										
	Leptochiton inquinatus					1																	
Class Gastropoda																							
	Epitonium sp.																			2			
	Maoricolpus roseus					1		1						2		1				17	2		2
	Zeacolpus sp.																			1			
	Philine sp.																						
	Relichna aupouria													1			1	1					
	Caecum digitulum														1					1			
	Sigapatella tenuis												2		2	6	3	2	1	2			
	Sigapatella sp.					1	1	1															
	Merelina sp.																						
	Tanea sp.																						
	Naticidae																						
	Rissoidae																1						
	Struthiolaria papulosa																						
	Tonna sp.																						
	Amalda northlandica					1		4										1	1				1
	Amalda sp.																						
	Austrofusus glans							1													1		
	Cominella quoyana																						
	Cominella virgata	1									1			1				1					
	Splendrillia aoteana																						
	Marginellidae																						
	Zeatrophon ambiguus															1							
	Turbonilla sp.				1																		
	Pyramidellidae																						
	Pleurobranchaea maculata																						
	Onchidella nigricans																						
	Cantharidus sp.																						
	Adelphotectonica reevei													1			1						
	Gastropoda Unid. Juv.	1									1									1	2		1
Class Bivalvia																							
	Hunkydora novozelandica																						
	Myadora antipodum							2									1						
	Myadora striata				1										1								
	Glycymeris modesta																						
	Glycymeris sp.																						
	Pratulum pulchellum																						
	Gari lineolata				1	1	1					1	1		1	2							
	Hiatula sp.	1				5	4				1		1		2		1	1		3		1	
	Pleuromeris zelandica								1														
	Pleuromeris sp.																			2		1	
	Purpurocardia purpurata									1													
	Limatula maoria													2		1				1		1	
	Corbula zelandica			1											1					1			
	Nucula nitidula				1	15		5					2	2		14	1	2		1			
	Atrina zelandica						1																
	Pecten novaezelandiae																						
	Dosinia lambata																						
	Dosinia subrosea																						
	Dosinia sp.							1									2						
	Notocallista multistriata																				2		2
	Tawera spissa																						
	Tawera sp.					2	1						5							1			
	Arthritica bifurca																						
	Myllita vivens																						
	Mysella sp.				1	4								5						2	1		4
	Scalpomactra scalpellum																						
	Diplodonta zelandica																						
	Bivalvia Unid. (juv)																						
Phylum Echinodermata																							
Class Echinoidea	*Echinocardium sp.*				1			3						1							1		
Class Ophiuroidea																	2					1	
Phylum Cnidaria																							
Class Anthozoa																							
	Anemone (unid.)							1										1			4		1
	Edwardsia sp.																						
	Arachnanthus sp.															1							
Order Scleractinia															15								
Class Hydrozoa																							
	Hydroida (thecate)														1								
Phylum Sipuncula																							
	Aspidosiphon sp.																					1	
	Nephasoma sp.																						
	Phascolion sp.																						
	Themiste sp.																				1		
Phylum Bryozoa																							
	Bryozoa (bushy)																						
	Bryozoa (discoid)																						
	Bryozoa (encrusting)																						
Phylum Porifera																							
	Sponge (bread)																						
	Sponge (cream Encrusting)													1	15			1					
	Sponge (glass)			1																			
Phylum Chordata																							
Class Ascidiacea																							
	Eugyra sp.																						
	Molgula sp.														2						1	2	
	Pyura sp.										1										1		
Class Leptocardii	*Epigonichthys hectori*	4	1		1	4	6	7	2		1		3	5		2		3	2		1	1	
Class Thaliacea	*Salpa sp*	11			1	1		5				1		4							2	4	1
Total Number of Individuals		164	57	129	678	418	323	761	53	12	396	614	88	491	334	125	122	56	110	507	670	227	528
Total Number of Species/Taxa		32	16	25	43	48	45	49	23	7	35	32	27	44	32	41	33	30	28	47	53	43	45
Shannon - Wiener Diversity Index		2.677	2.136	2.177	2.408	2.928	2.225	2.675	2.605	1.699	1.371	1.988	2.831	2.527	1.557	3.372	3.021	3.200	2.558	2.456	2.429	2.201	2.159

Table 29 Benthic Biota Data Control, 2017 (Number per sample)

Taxa	Transect	T9								TC			T10							
	Site	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
Phylum Annelida																				
Class Polychaeta																				
Order Sabellida	*Euchone pallida*					1		1	2			3	1							
	Sabellidae								2		1	4		1				2	2	1
	Hydroides sp.																			
	Serpula sp.				1															
	Serpulidae																			
Order Spionida	*Phyllochaetopterus socialis*																			
	Aonides oxycephala																			
	Boccardia sp.																			
	Paraprionospio pinnata	1							2			6						1		
	Prionospio aucklandica	1																		
	Prionospio multicristata	1	1		2		29	1		1	2		19		13	5			3	3
	Prionospio sp.	4	15	2	4	5	69	3		7	2	5	13	2	60	30	17	2	10	2
	Spio sp.					1				2		1	2				2		1	
	Spiophanes kroyeri											2								
	Spiophanes modestus	90	11		2		6	92	165	7	1	193	21	6	89	19	27	188	3	1
Order Terebellida	Ampharetidae				1			11	51			57	1				2	74	2	4
	Cirratulidae	3			1		4		1		3	2	14	1	3	2	1	3	1	
	Flabelligeridae											2								
	Lagis australis																			
	Terebellidae	2			1	1			1	4	3	1	10	3	4	2	1	2	1	3
Order Eunicida	Dorvilleidae						2		1											
	Marphysa sp.																			
	Lumbrineridae		1							8		1	1	2						
	Nothria sp.	1	1			1	1	5	8		4	8			1	2	1	18		5
	Onuphis aucklandensis											2								
	Onuphidae							1												
Order Phyllodocida	Glyceridae						2					1				1		1		
	Goniadidae											9	1	1	1		2	1		
	Hesionidae								1					1						
	Aglaophamus sp.			1								2	1	1	1				1	
	Neanthes cricognatha																			
	Perinereis vallata																		1	
	Phyllodocidae	4			1	1		5	4	4	1	4	6	3	9	3		3		
	Polynoidae																			
	Sigalionidae	2	1	1		1	1			3	1	2	1	2	2			3	3	2
	Sphaerosyllis sp.		3		1		3			1					3					
	Syllidae		2		2		6	1	1	3	3	1	4		3		1	1	2	5
	Magelona dakini					1	1					1		3						
Order Capitellida	*Barantolla lepte*				1													8		
	Capitella capitata																			
	Heteromastus filiformis																			
	Notomastus zeylanicus				1						2									
Order Cossurida	*Cossura consimilis*																			
Order Opheliida	*Armandia maculata*	1					1	4	2	1			29	1	12	2	1			4
Order Orbiniida	*Leodamas cylindrifer*								2			1						3		1
	Orbinia papillosa									1	2	5		1						
	Maldanidae	7	3		1	1		2	1	5		12	8	2	20	10	2	3		2
	Aricidea sp.									1		17				1	3	5		
	Paraonidae	1												1						
	Travisia sp.	1					1			3			3	1	1			3		
Phylum Hemichordata			1																	
Phylum Cephalorhyncha	Priapulidae																			
Phylum Phoronida	*Phoronis sp.*	7	2			1			1			3					2	1		
Phylum Nemertea							1		1		1	1	1		2		1	3	1	
Phylum Arthropoda																				
Class Hexanauplia	Copepoda																			
Class Malacostraca																				
Order Amphipoda																				
	Caprellidae	1																		
	Haustoriidae	12	20	2		3			11	2	1	11	2		8	9	9	8	2	
	Lysianassidae	30	13	1	2		1	3	21	5	1	19	1	2	32	11	2	2	4	1
	Oedicerotidae																			
	Phoxocephalidae	64	49	3	9	3	3	16	33	8		5	5	8	156	38	13	5	11	4
	Stegocephalidae																			
	Talitridae																			
	Amphipoda Unid.	17	19	2	9	5	41	3	37	29	53	14	134	18	35	22	9	10	71	41
Order Cumacea		10	10		2	5		1	54	6	3	41		4	15	3	3	24	17	
Order Decapoda																				
	Alpheus sp.										1									
	Philocheras australis																		1	
	Halicarcinus cookii			2		1														
	Halicarcinus sp.																			
	Ebalia laevis											1				1	1		1	
	Notomithrax sp.						2				1									
	Natantia Unid.											1								
	Nectocarcinus antarcticus																			
	Pagurus sp.	1	1		4		43		5	1	4	9	4	4	4	1	3	6	13	4
	Nepinnotheres novaezelandiae																			
	Liocarcinus corrugatus																			
	Petrolisthes novaezelandiae			2					1											
	Processa sp.																			
	Upogebia sp.																			
	Decapoda (larvae Unid.)	1			1				3	1	1	1						1		
Order Isopoda																				
	Anthuridae	2	1						1	1		3		5	7	3	1	3	1	2
	Eurylana arcuata						1				1								1	
	Pseudaega sp.	2																		
	Munna neozelanica											1								
	Uromunna schauinslandi	1			1				1											
	Cassidina typa								1											
	Exosphaeroma sp.	1																		
	Paravireia sp.	2																		
	Valvifera																			
Order Leptostraca	*Nebalia sp.*																			
Order Mysida						1				2	1									
Order Podocopida	*Paracypris zealandica*	10	12						33						2			2		
Order Stomatopoda																				
Order Tanaidacea			1						5	1	1			2				1		
Class Ostracoda																				
	Diasterope grisea	14	7		2	1				6		1				3	1	2		
	Leuroleberis zealandica									2		3								
	Parasterope quadrata		1							1	2	1		1	5					
	Cypridinodes sp.	16	13			1	2	1	20	5	7	35			6			20		6
	Pleoschisma agilis									1	1									
	Scleroconcha sp.						2		1											

Taxa	Transect	T9								TC			T10							
	Site	W	0	1	2	3	4	5	E	W	M	E	W	0	1	2	3	4	5	E
	Cymbicopia sp.	3	2								4	1								
	Copytus novaezealandiae								1											
	Bradleya sp.		2								1									
	Ostracoda																			
Phylum Mollusca																				
Class Polyplacophora																				
	Ischnochiton maorianus						2													
	Leptochiton inquinatus						3				4									1
Class Gastropoda																				
	Epitonium sp.																			
	Maoricolpus roseus	1			3				2						1	3	1	3	2	1
	Zeacolpus sp.								1											
	Philine sp.																			
	Relichna aupouria	1															1			
	Caecum digitulum																			
	Sigapatella tenuis						1						1		1					
	Sigapatella sp.																			
	Merelina sp.											1								
	Tanea sp.																			
	Naticidae																			
	Rissoidae		1							2										
	Struthiolaria papulosa													1		1				
	Tonna sp.																			
	Amalda northlandica									1						1				
	Amalda sp.	2													2					
	Austrofusus glans	1																1		
	Cominella quoyana												1							
	Cominella virgata									1										
	Splendrillia aoteana													1						
	Marginellidae																			
	Zeatrophon ambiguus																			
	Turbonilla sp.																			
	Pyramidellidae																			
	Pleurobranchaea maculata														1					
	Onchidella nigricans									1										
	Cantharidus sp.																			
	Adelphotectonica reevei	1	2																	
	Gastropoda Unid. Juv.								1		1	1						1		
Class Bivalvia																				
	Hunkydora novozelandica									1								1		
	Myadora antipodum		1							1										
	Myadora striata						1													
	Glycymeris modesta																			
	Glycymeris sp.																			
	Pratulum pulchellum		1									1						1	1	
	Gari lineolata						1					1								
	Hiatula sp.				1		1			2										
	Pleuromeris zelandica				1	1					1									
	Pleuromeris sp.																			
	Purpurocardia purpurata																			
	Limatula maoria																		1	
	Corbula zelandica										2									
	Nucula nitidula		1		1	1			2	6	3		6	1				1	2	
	Atrina zelandica																			
	Pecten novaezelandiae																			
	Dosinia lambata																			
	Dosinia subrosea										1									
	Dosinia sp.	1	1										1			1				
	Notocallista multistriata																			
	Tawera spissa												73		1					
	Tawera sp.									1										
	Arthritica bifurca								1											
	Myllita vivens																			
	Mysella sp.	1	2						2											
	Scalpomactra scalpellum			1															1	
	Diplodonta zelandica												2							
	Bivalvia Unid. (juv)																			
Phylum Echinodermata																				
Class Echinoidea	*Echinocardium sp.*									1										
Class Ophiuroidea											1							1		
Phylum Cnidaria																				
Class Anthozoa																				
	Anemone (unid.)																	4	1	
	Edwardsia sp.																	1		
	Arachnanthus sp.											1								
Order Scleractinia																	1			
Class Hydrozoa																				
	Hydroida (thecate)																			
Phylum Sipuncula																				
	Aspidosiphon sp.											1								
	Nephasoma sp.																			
	Phascolion sp.														1					
	Themiste sp.																			
Phylum Bryozoa																				
	Bryozoa (bushy)																			
	Bryozoa (discoid)		1																	
	Bryozoa (encrusting)																	1		
Phylum Porifera																				
	Sponge (bread)																			
	Sponge (cream Encrusting)						2							1						
	Sponge (glass)																			
Phylum Chordata																				
Class Ascidiacea																				
	Eugyra sp.																			
	Molgula sp.									1		1								
	Pyura sp.																			1
Class Leptocardii	*Epigonichthys hectori*	1	1		1	1	3		1	1	2	1	1	2	11	2	1		1	1
Class Thaliacea	*Salpa sp*	7					2		19			6	1	1			1	2		1
Total Number of Individuals		329	203	17	56	37	238	150	503	141	124	507	368	83	512	176	110	426	162	96
Total Number of Species/Taxa		41	34	10	26	21	31	16	41	42	37	52	31	31	33	25	28	43	30	23
Shannon - Wiener Diversity Index		2.619	2.744	2.232	2.914	2.780	2.300	1.546	2.480	3.219	2.623	2.571	2.253	2.995	2.423	2.529	2.625	2.253	2.265	2.341

Table 30 Dredge Tow Data Area 1 and Control Area 2017

Site	Date	Time	Distance	Area	Name	Species	Size	Size			Density	
			m	m²			mm	n	x	sd	x	/100m²
T0 A	15 Dec 2017	16:00	97	58.2								
					Comb Star	*Astropecten polycanthus*	200	1	200.00		1	1.72
					Ostrich foot	*Struthiolaria papulosa*					1	1.72
T0 B	18 Dec 2017	11:50	94	56.4								
					Comb Star	*Astropecten polycanthus*	115 123 125	3	121.00	4.32	3	5.32
					Star fish	*Luidia australiae*	142	1	142.00		1	1.77
					Fan shell	*Mesopeplum convexum*					3	5.32
					Whelk	*Monoplex parthenopeus*	62	1	62.00		1	1.77
					Scallop	*Pecten novaezelandiae*	82 88 75 88 72 56 69	7	75.71	10.62	7	12.41
T0 C	18 Dec 2017	11:40	99	59.4								
					Comb Star	*Astropecten polycanthus*	50 52 71 90 89	5	70.40	17.23	5	
					Scallop	*Pecten novaezelandiae*	126 94	2	110.00	16.00	2	3.37
					Sponge	Orange finger					1	1.638
T2 A	15 Dec 2017	16:20	100	60								
					Scallop	*Pecten novaezelandiae*	77	1	77.00		1	1.67
T2 B	18 Dec 2017	11:20	101	60.6								
					Comb Star	*Astropecten polycanthus*	96	1	96.00		1	1.65
					Star fish	*Luidia australiae*	182	1	182.00		1	1.65
					Scallop	*Pecten novaezelandiae*	50 55 58 68 86 92	6	68.17	15.77	6	9.90
					Sponge	Grey finger					1	1.65
T2 C	18 Dec 2017	11:10	100	60								
					Hermit crab						1	1.67
					Fan shell	*Mesopeplum convexum*	33	1	33.00		1	1.67
					Limpet	*Notocrater craticulatus*					1	1.67
					Scallop	*Pecten novaezelandiae*	68	1	68.00		1	1.67
					Sponge	Orange finger					1	1.67
T4 A	15 Dec 2017	16:30	125	75								
					Bivalve	*Irus reflexus*					1	1.33
					Borer	*Pholadidea tridens*					27	36.00
					Bivalve	*Zemysina striatula*					1	1.33
T4 B	18 Dec 2017	10:38	100	60								
					Comb Star	*Astropecten polycanthus*	130	1	130.00		1	1.67
					Scallop	*Pecten novaezelandiae*	52 53 68 94	4	66.75	16.96	4	6.67
T4 C	18 Dec 2017	10:55	100	60								
					Comb Star	*Astropecten polycanthus*	116	1	116.00		1	1.67
					Chiton						1	1.67
					Hermit crab						1	1.67
					Juvenile swimming crab						3	5.00
					Fan shell	*Mesopeplum convexum*	40	1	40.00		1	1.67
					Scallop	*Pecten novaezelandiae*	54 45	2	49.50	4.50	2	3.33
					Sponge	Grey finger					1	1.67
					Carrier shell	*Xenophora neozelanica*	34 32	2	33.00	1.00	2	3.33
T6 A	18 Dec 2017	10:30	100	60								
					Ascidian						29	48.33
					Comb Star	*Astropecten polycanthus*	115 95 121 98	4	107.25	11.01	4	6.67
					Octopus	*Octopus huttoni*					1	1.67
					Scallop	*Pecten novaezelandiae*	98 95 88 92 93 96 98 91 89 96 85 87 85 101 98 90 61 61 57 68 83 95 98 68 101 91 86 86 86 92 93 89	32	87.41	11.64	32	53.33
T6 B	18 Dec 2017	10:20	100	60								
					Comb Star	*Astropecten polycanthus*	100 114 123 108	4	111.25	8.41	4	6.67
					Whelk	*Cominella adspersa*	43	1	43.00		1	1.67
					Juvenile swimming crab						1	1.67
					Scallop	*Pecten novaezelandiae*	85 92 98 84 91 82 71 61 94 67	10	82.50	11.74	10	16.67
					Ostrich foot	*Struthiolaria vermis*	49	1	49.00		1	1.67
					Bivalve	*Zemysina striatula*					1	1.67
T6 C	18 Dec 2017	10:05	100	60								
					Olive shell	*Amalda novaezelandiae*					1	1.67
					Comb Star	*Astropecten polycanthus*	100	1	100.00		1	1.67
					chiton						2	3.33
					Hermit crab						1	1.67
					Star fish	*Luidia australiae*	127	1	127.00		1	1.67
					Fan shell	*Mesopeplum convexum*					1	1.67
					Whelk	*Monoplex parthenopeus*	70	1	70.00		1	1.67
					Scallop	*Pecten novaezelandiae*	62 76 75 73 81 82 100 79 83 86 73 64 79 96 82 83 87 78 84 72 82 76	22	79.68	8.50	22	36.67
					Sponge	Grey finger					1	1.67
					Sponge	Orange finger					1	1.67
					Sponge	Grey spikey					1	1.67
					Top shell	*Trochus sp.*					1	1.67
T8 A	18 Dec 2017	9:25	100	60								
					Ascidian						2	3.33
					Comb Star	*Astropecten polycanthus*	116 127	2	121.50	5.50	2	3.33
					Whelk	*Monoplex parthenopeus*	65	1	65.00		1	1.67
					Scallop	*Pecten novaezelandiae*	105 95 97	3	99.00	4.32	3	5.00
T8 B	18 Dec 2017	9:35	99	59.4								
					Ascidian						2	3.37
					Comb Star	*Astropecten polycanthus*	101 115	2	108.00	.7.00	2	3.37
					chiton						2	3.37
					Hermit crab						2	3.37
					Fan shell	*Mesopeplum convexum*					1	1.68
					Scallop	*Pecten novaezelandiae*	78 84 73 55 60 93 90 70 86 101	10	79.00	13.89	10	16.84
T8 C	18 Dec 2017	9:45	99	59.4								
					Scallop	*Pecten novaezelandiae*	80 94 93 91 72 107	6	89.50	11.09	6	10.10
					Ascidian						5	.8.42

Site	Date	Time	Distance m	Area m²	Name	Species	Size mm	Size n	Size x	Size sd	Density x	Density /100m²
					Oyster	*Anomia trigonopsis*					2	3.37
TC A	18 Dec 2017	9:15	100	60								
					Ascidian						6	10.00
					Comb Star	*Astropecten polycanthus*	142 112 101	3	118.33	17.33	3	5.00
					Hermit crab						1	1.67
					Scallop	*Pecten novaezelandiae*	68 83 91 95 93 70 83	7	83.29	10.01	7	11.67
					Ostrich foot	*Struthiolaria papulosa*	62	1	62.00		1	1.67
TC B	18 Dec 2017	8:45	100	60								
					Ascidian						0	0.00
					Comb Star	*Astropecten polycanthus*	119 130 110 113 115	5	117.40	6.95	5	8.33
					Hermit crab						5	8.33
					Snail	*Maoricolpus roseus*					1	1.67
					Whelk	*Murexsul espinosus*					2	3.33
					Scallop	*Pecten novaezelandiae*	68 86 54 85 104 85 86 87 78 89 78 92 88 86 82 58 101 56	10	82.20	12.66	10	16.67
					Sponge	Grey finger					1	1.67
TC C	18 Dec 2017	8:30	100	60								
					Comb Star	*Astropecten polycanthus*	130 85	2	107.50	22.50	2	3.33
					Whelk	*Cominella quoyana*					1	1.67
					Juvenile swimming crab						1	1.67
					Star fish	*Luidia australiae*	165	1	165.00		1	1.67
					Fan shell	*Mesopeplum convexum*					1	1.67
					Scallop	*Pecten novaezelandiae*	80 82	2	81.00	1.00	2	3.33
					Whelk	*Penion sulcatus*	122	1	122.00		1	1.67
					Top shell	*Trochus sp.*					2	3.33
					Carrier shell	*Xenophora neozelanica*	76	1	76.00		1	1.67